AGRONOMY SEMINAR
305 DAVENPORT HALL

ЧВОВЕДЕНИЕ

SOVIET SOIL SCIENCE

12

DECEMBER 1960

A TRANSLATION
OF POCHVOVEDENIYE

★

AMERICAN INSTITUTE
OF BIOLOGICAL SCIENCES
2000 P STREET, N.W.
WASHINGTON 6, D. C.

SOVIET SOIL SCIENCE

. A. P. MAZURAK, *Editor*
Department of Agronomy, University of Nebraska

Patricia Haley
Assistant Editor

American Institute of Biological Sciences

Officers
Tracy M. Sonneborn, *President*
Bernard S. Meyer, *Vice-President*
F. P. Cullinan, *Secretary-Treasurer*

Executive Director
Hiden T. Cox

Chairman,
Committee on Translations
Fred R. Cagle

Director of Publications
Francis C. Harwood

Governing Board
George Beadle
Albert P. Blair
Fred R. Cagle
David E. Davis
E. L. Dulaney
Wallace O. Fenn
Clifford Grobstein
A. M. Guhl
Freeman S. Howlett
Paul J. Kramer
W. Gardner Lynn
Dorothy Matala
George L. McNew
Bernard S. Meyer
Fred S. Orcutt
F. W. Poos
Roger D. Reid
Reed C. Rollins
William Steere
John A. Stevenson
Karl A. Stiles
Carl P. Swanson
Kenneth Thimann
Arthur C. Walton
Richard G. Zweifel

The translation and publication of this and other Russian language biological journals and monographs is a project of the American Institute of Biological Sciences. This project is supported by grants from the National Science Foundation. Each publication is a cover-to-cover translation of its Soviet counterpart and the contents are only those of the original authors.

Pochvovedeniye in English translation bears the Soviet issue numbers. The Soviet journal carries no volume numbers. Translation begins with Number 1, the January 1958 issue. It is published in the same number of issues per year as the original Soviet journals: 12 issues.

Digitized by the Internet Archive
in 2024
https://archive.org/details/eurasian-soil-science_1960-12_12

translated and produced by
ROYER & ROGER, INC.
INTERNATIONAL DIVISION

Subscription Prices:

$40.00 per year, individuals and industrial libraries
20.00 per year, university and non-profit libraries
3.00 additional to each price for foreign orders
4.50 each, single copies

Order from:

American Institute of Biological Sciences
2000 P Street, N.W., Washington 6, D.C.

© 1961 American Institute of Biological Sciences

SOVIET SOIL SCIENCE

translation of the monthly journal—POCHVOVEDENIYE—
publication of the V. V. Dokuchayev Institute of Soil Science,
cademy of Sciences, USSR. A journal founded in 1899.

ochvovedeniye Editorial Board: I. V. Tyurin (editor-in-chief), I. N. Antipov-Karatayev, N. I. orbunov, K. P. Gorshenin. A. A. Zavalishin, V. N. Zavaritskii, S. V. Zonn (assistant editor), . K. Kedrov-Zikhman, V. M. Klechkovskii, V. A. Kovda, M. M. Kononova (assistant editor), Ya. . Peive, I. I. Sinyagin, A. V. Sokolov

---

12: December 1960 Translation printed: January 1962

CONTENTS

	Page	Russian Page
OLOGICAL ENERGY EXCHANGE PROCESSES IN TROPICAL FOREST SOILS, by S. V. Zonn and Li Chen-Kuei	1265	1
ME FEATURES OF HUMUS FORMATION IN MOUNTAIN SOILS OF NORTHERN TYAN'-SHAN', by I. A. Assing	1277	16
YSICAL PROPERTIES OF COMPACT CHERNOZEMS, by Ye. S. Blazhniy and Yu. N. Bagrov	1283	23
LCULATION OF THE MIGRATION OF CERTAIN COMPOUNDS IN SOIL BY USING CHROMATOGRAPHIC COLUMNS OF LYSIMETERS, by I. S. Kaurichev and Ye. M. Nozdrunova	1289	30
MUS DISTRIBUTION IN THE TUNDRA SOILS OF NORTHERN YAKUTIA, by N. A. Karavayeva and V. O. Targul'yan	1293	36
E OF SPRINKLING IRRIGATION IN RECLAMATION OF SANDY SOILS ON THE INCHAS FARM IN EGYPT, by Ahmed Hamal Abd El-Sami	1301	46
E ROLE OF SHRUB ROOTS IN SUPPLYING SOIL WITH ORGANIC MATTER AND NITROGEN, by P. P. Pokhiton	1311	57
MATOMELANIC ACIDS OF FOSSIL COALS, by T. A. Kukharenko and L. N. Yekaterinina	1317	64
FECT OF WIND EROSION UPON SOME PHYSICAL AND CHEMICAL PROPERTIES OF SOILS, by T. F. Yakubov	1323	71

METHODS

ARACTERISTICS OF NORTHWEST CAUCASIAN BROWN FOREST SOILS, by B. D. Zaytsev	1327	76
NERALOGICAL COMPOSITION OF THE CLAY FRACTIONS OF CRIMEAN CHERNOZEMS, by L. P. Abrukova	1334	83
FECT OF ETHYLENDIAMINE TETRAACETATE ON THE BEHAVIOR OF COBALT IN SOIL AND PLANTS, by N. V. Kulikov	1340	89
OLOGICAL ACTIVITY OF FOREST SOILS IN THE KOLA PENINSULA, by A. L. Parshevnikov	1346	95

	Page	Russian Page
FORMATION OF THE CHEMICAL COMPOSITION OF SOIL SOLUTIONS UNDER THE INFLUENCE OF GROUND WATER, by P. I. Shavrygin	1349	98
USE OF INTERFEROMETRY IN SOIL CHEMICAL STUDIES, by Yu. A. Polyakov and N. S. Germogenova	1353	102
CHRONICLE		
VLADIMIR PETROVICH BUSHINSKIY, by a group of colleagues	1459	108
YEVGENIY PETROVICH TROITSKIY, by Soil Department, Biological and Soil Faculty of Moscow State University	1361	110
ALEKSEY ALEKSANDROVICH STOL'GANE, by a group of colleagues	1362	112
BIBLIOGRAPHY	1363	114
INDEX	1371	122

IOLOGICAL ENERGY EXCHANGE PROCESSES N TROPICAL FOREST SOILS

V. ZONN and LI CHEN-KUEI,[1] Laboratory of Forestry, Academy of Sciences, USSR, and Soil stitute, Chinese Academy of Sciences

The processes of energy exchange in forest ogeocenoses are, as Sukachev (4) has empha- zed, one of the main indications of differ- ices in their formation and evolution. Yet to is day very little has been done in studying ese processes; only recently have they begun attract investigators' attention (1). One indi- tion of differences in the energy exchange ocesses of forest biogeocenoses is the rate of O_2 production from decomposing litter-fall and il humus, along with the CO_2 and oxygen con- nt in the soil air.

By starting with the data on the liberated CO_2 om litter in the surface air layer, its entry to the soil, and the variation of the CO_2:O_2 tio in the soil air, one can arrive not only at qualitative evaluation of the energy exchange the biogeocenoses but also at a comparison the soil formation energetics in them.

From a study of the gas regime in forest ogeocenoses (natural and artificial) in Soviet ırope it has been possible to establish values r the accumulation of CO_2 and O_2 and to dis- ver some of the characteristics of this accum- ation governed by hydrothermal conditions, e composition of the trees (2, 5), and other fac- rs. It has been shown that the relatively eatest CO_2 production occurs under artificial rest biogeocenoses developing on ordinary ernozems in the steppe. In all other bio- ocenoses, whether more southerly or more rtherly than these, CO_2 production is less. ne pattern fits in with differences in the ac- mulation and decomposition rate of litter d the amount and composition of humic sub- ances in soils formed under conditions of astic seasonal variation in the hydrothermal gime.

So far there has been no similar investigation forest biogeocenoses under tropical condi- ons where the rate of development is different. t it is most important that such investigations should be made, since biogeocenoses of this kind form a greater mass of organic substances than any other, and a considerable part of this mass enters the soil surface in the form of annual litter fall. The decomposition of litter fall goes on throughout the year; yet the rate of the biological processes determining the decomposition picture remains unstudied.

In an attempt to fill this gap an extensive study of soil process dynamics, including the gas regime, has been undertaken as part of the biogeocenotic study of nature in China's tropical forests. The work is being done at a forest biogeocenotic station set up for the purpose by the Chinese Academy of Sciences, with the participation of the Laboratory of Forestry of the USSR Academy of Sciences. The station is situated in the southwestern part of Yunnan, 90 km south of Cheli in the autonomous district of Sishanban, near the village of Damulung, 10-12 km from the Burmese frontier.[2]

Objectives of Investigation

The investigations are being made in two types of forest biogeocenoses:

1. a moist tropical evergreen *Geronniera* area with fern cover, where the main tree species in the first story are *Geronniera sulaguala*, *Xanthophyllum*, *Knemma liniifolia* and others, while the fern *Plyocnemia* predominates in the grass cover;

2. a secondary bamboo forest consisting of *Phylostachys* sp.[3]

The soil observations and investigations were per- med by the following young soil scientists: Kao- n, Che-Ying, Chen Shih-Wen, and Wang Kuei-Hai. emical and particle-size analyses were performed Chao Tsen Chang, Tang Tseng Cheng, and Li h Hao.

[2] The work of the station is under the general direction of Academician V.N. Sukachev. The soil studies are under the immediate direction of the present authors.

[3] Identified by N.V. Dylis. It is still a moot point whether the bamboo overgrowth belongs to the forests or not. We are provisionally calling it a forest since it has certain features in common with a typical tropical forest (such as periodicity of fall of part of the organic mass and so forth). We shall henceforward call the first type of forest evergreen and the second bamboo.

Table 1

Particle-size analysis of soils (Kachinskiy method) in percentages

Horizons and depth, cm		Particle diameter, mm						
		1—0,25	0,25—0,05	0,05—0,01	0,01—0,005	0,005—0,001	<0,001	<0,01
Evergreen forest soil								
A	1—10	8,9	19,4	12,4	7,1	14,3	37,9	59,3
B	59—104	6,8	15,2	16,6	7,6	16,2	37,5	61,3
C	132 and below	6,5	15,6	10,8	5,7	17,2	45,1	67,0
Bamboo forest soil								
A	0—19	3,1	5,4	14,9	16,5	34,2	25,8	76,6
B	60—100	2,9	3,2	10,3	6,7	31,7	45,0	83,5
C	150—160	3,1	4,4	16,2	3,6	31,6	41,1	76,4

Note: Comma represents decimal point.

Both types are developing on soils where the soil formation is of a clearly tropical character but there are substantial differences between them. The first type is growing on tropical yellow earths, the second on red earths, both soils having developed on a red-colored weathered crust. The indices shown in the tables below illustrate the differences between the two.

In regard to particle-size analyses (Table 1) the first soil is distinguished by its higher content in the 1-0.05 mm diameter fraction and its lower content in the remaining fractions, particularly those consisting of particles <0.005 mm in diameter. The second is more clayey in the B and C horizons. In the A horizon it contains appreciably fewer particles <0.001 mm in diameter than the first.

The clay accumulation in the soil under the bamboo forest is in conformity with the high R_2O_3 and Al_2O_3 content in this soil, clearly reflected in the $SiO_2:R_2O_3$ and $SiO_2:Al_2O_3$ ratios in both soils (Table 2).

The C horizon of both soils shows a certain uniformity in mineral composition, but the A and B horizons under the bamboo are more allitic, as can be seen from the lower SiO_2 content in it. In regard to pH, total exchangeable cations and exchangeable H content there are even greater differences between the two soils (Table 3).

The soil in the evergreen forest is more acid and has a greater total of exchangeable cations, with exchangeable H predominating. The soil under the bamboo forest is less acid and has a lower content in exchangeable cations, with appreciably less exchangeable H. These differences may be connected with differences in the nature of the biological circulation, particularly the energetics of soil formation in these biogeocenoses. They are most probably due to dissimilarity between the two soils as regards intake of organic matter as well as the rate, character and conditions of its decomposition.

Accumulation and Decomposition of Litter

Observations made from March 1959 to February 1960 inclusive showed a peculiar pattern of change in the litter contents (Fig. 1, A). The maximum amount of litter, about 2 metric tons per hectare in the evergreen and 2.3 metric tons per hectare in the bamboo

Table 2

$SiO_2:R_2O_3$ and $SiO_2:Al_2O_3$ ratios in tropical forest soils

Horizons and depths, cm		Under bamboo		Horizons and depths, cm		Under evergreen	
		$SiO_2:R_2O_3$	$SiO_2:Al_2O_3$			$SiO_2:R_2O_3$	$SiO_2:Al_2O_3$
A	0—19	1,32	1,60	A	0—10	1,43	1,92
B	60—100	1,31	1,53	B	40—70	1,39	1,68
C	150 and below	1,45	1,79	C	132	1,45	1,78

Note: Comma represents decimal point.

Table 3

Physical and chemical properties of soils

Depth, cm	pH	Total exchange cations	Exchange-able H	Depth, cm	pH	Total exchange cations	Exchangeable H
		in meq				in meq	
Evergreen forest soil				Bamboo forest soil			
0—10	4,65	4,92	3,05	0—19	5,65	5,14	0,78
20—70	4,86	4,89	2,94	60—100	5,14	3,15	1,90
132 and be-low	5,36	3,11	2,21	150—160	5,64	2,89	0,40

Note: Comma represents decimal point.

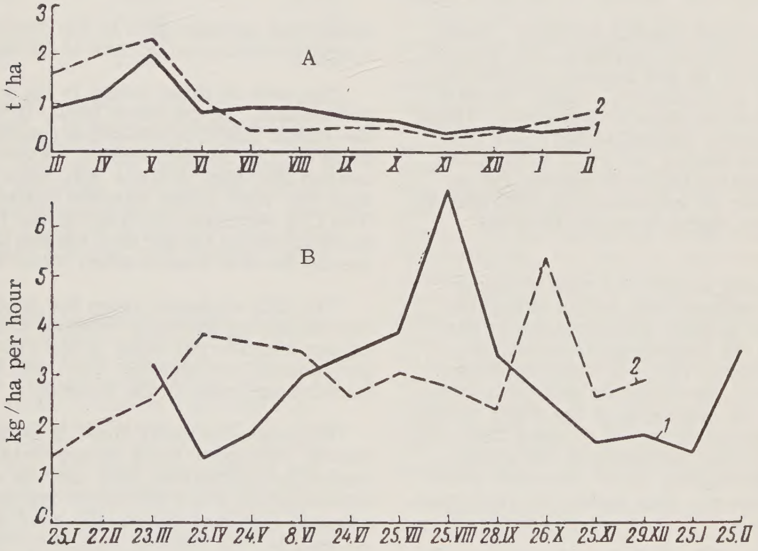


Fig. 1. - A - Change in litter contents in tropical forest biogeocenosis soils; B - change in CO_2 evolution from soil surface, kg per hectare. 1 - under evergreen; 2 - under bamboo.

eocenoses, was observed in May.[4] From to November litter decomposition was in- ive and the litter decreased to 460 kg per are, or by 79.6%, in the first biogeocenosis to 313 kg per hectare, or by 85.9%, in the ond. Much intensity of decomposition rs during the rainy season, particularly May to October. November to February e foggy season and March to April the dry on. The characteristic distribution of ipitation and air temperature under the py of the evergreen biogeocenosis is shown able 4.

With such a hydrothermal regime the activity of microorganisms and animals is assured throughout the year, along with continuity of the biochemical conversion of litter fall. The latter processes can slow down only in the period from December to February, when minimum temperatures fall to 12.1°C and mean temperatures to 15.6°C. Air temperatures in the dry season (March and April) are highest, as a result of intensive evapotranspiration of soil moisture and increased mineralization of organic matter in the litter.

Intensive litter decomposition continues in November despite the dry period, owing to the accumulation of moisture during the preceding months and the higher air temperature. Later, decomposition slows down and in particular very dry months there is even some increase in the litter content as a result of leaf-fall and,

---

reshly fallen leaves were removed before the fall was measured. Measurement was replicated mes.

Table 4

Amount of precipitation and air temperature by months

Elements	1959										1960	
	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.
Precipitation, mm	—	Not det'd.[a]	302,6	295,1	238,0	210,9	194,6	38,5	0,2	43,6	68,2	1,7
Temperature, ^{0}C												
Maximum	28,5	31,8	28,6	27,8	27,3	26,9	25,7	24,4	23,2	21,6	20,4	22,8
Minimum	18,6	16,0	19,5	21,4	21,5	21,7	20,4	18,2	15,3	14,4	12,1	12,7
Average	19,2	23,5	23,5	24,0	24,0	23,9	22,7	20,0	19,9	17,7	15,6	17,0

[a] March and April precipitation measurement not accurate; in the open, 16.1 mm fell in March and 23.5 mm in April.

Note: Comma represents decimal point.

possibly, reduced soil animal activity. Under the evergreen forest, for example, the amount of litter fall by 91.3 kg per hectare or 18% between December and January. Under the bamboo the litter contents start to increase. There is accordingly only a negligible decrease in the litter contents during the foggy season and some increase during the arid season; but in both seasons there is sufficient CO_2 liberated to indicate that litter decay does not entirely cease.

During the rainy season the rate of decay is higher in the bamboo than in the evergreen litter despite the greater accumulation of the former towards the beginning of the season. In general, however, there is little difference in regard to litter accumulation and decomposition. Towards the beginning of the foggy season the amount of litter decreases to about 79%-80% as compared with the beginning of the rains; decomposition is slightly more intensive under the bamboo, however, than under the evergreen.

CO_2 Liberated from Litter

The CO_2 is evolved from the litter surface throughout the year (Fig. 1, B).[5] With a CO_2 content in the surface air layer varying from 0.146 to 0.315 mg per liter under the evergreen and from 0.197 to 0.360 mg per liter under the bamboo, the litter gives off large amounts of CO_2 in the course of one hour.

The annual dynamics of CO_2 evolution varies. In the moist evergreen biogeocenosis comparatively small amounts of CO_2 form during the dry and foggy seasons. By the beginning of the rainy season litter decay intensifies and CO_2 liberation increases towards August, when rainfall diminishes slightly. In the bamboo biogeocenosis the annual cycle of CO_2 liberation is more uniform, the first maximum occurring at the end of the dry and the beginning of the rainy season; CO_2 evolution then decreases during the greater part of the rainy season and a second maximum occurs in October.

The rate of litter decay in the evergreen biogeocenosis, on the other hand, is higher, with the result that CO_2 evolution reaches its maximum during the wet season. Even in the dry season the litter suffers less mineralization than the litter in the bamboo biogeocenosis. The CO_2 evolution declines at the time of maximum litterfall during this season and increases during the wet season when litter-fall is slight.

The CO_2 evolution from the litter surface varies during the year between 1.301 and 6.664 kg per hectare per hour in the evergreen biogeocenosis and between 1.337 and 4.903 kg per hectare per hour in the bamboo.

Whereas the lower limit is similar in both cases, the upper limit is appreciably higher under the evergreen; this may be an indirect indication of more intensive decomposition of organic residues during the west season. It is hard to tell whether this is a connection with the quality of the organic litter or with differences in the activity of microorganisms and soi animals, owing to lack of data. The role of animals inhabiting tropical soils is immense, because there are so many of them; it has been visually observed that the soil termite populati under bamboo forest is appreciably larger than under the evergreen in the latter, the termites act as cleaners, eliminating an immense amou of organic residue, whereas in the bamboo forests they seem to regulate the bamboo densi in the area they occupy.[6]

In the bamboo forests termites settle mainly in the soil; in the evergreen forests they settle both in the soil and in tree trunks. It is hard to say whether this differentiation is due to the species of the termites or to adaptation by a particular species to different conditions. It is noteworthy that the two biogeocenoses differ not only in regard to the biochemical action of ir termites but also in regard to the physi- properties of the red-colored soils, which fer greatly in porosity and water permeability.

---

[5] Determined by the Ludegaord method, Makarov's modification.

[6] This point will be treated more fully in a separate paper.

The mean diameter of the termite passages ries from 0.7-0.5 to 1-3 cm but cavities 15-20 15-25 cm with clay walls are found. These ssages penetrate the soil to a depth of 60-70 and sometimes lower. The termites not y re-work the organic and mineral mass but loubtedly make for a higher CO_2 and a lower content in the soil air.

The following values, relating to the ever- een biogeocenosis will give an idea of the h CO_2 evolution from organic litter material re.

Date	kg per hectare per hour in litter	 in soil
rch 23, 1959	3.225	1.561
y 25, 1959	3.849	3.574
gust 25, 1959	6.664	3.735
ot. 28, 1959	3.358	1.344
ı. 25, 1960	1.404	0.953
b. 25, 1960	3.445	0.964

The CO_2 evolution from the litter was higher n from the soil. In the rainy season (July- otember) this difference was in some cases oothed (July) whereas in others (August) it owed a sharp increase, even though the soil isture was the same in these months, amount- to 41%. The greatest difference was noted September when the soil was wettest (up to % moisture).

In the dry months (January-March) differ- ces in the CO_2 evolution were stable, the er producing more than the soil. Soil mois- e during this season varied from 29%-31%. pronounced relationship between the CO_2 olution and the soil moisture during the rainy ason was observed. All we can say is that en the litter and soil were excessively wet ptember 28) the CO_2 evolution decreased, ticularly from the soil surface, possibly ing to inhibition of the activity of microorgan- ns, particularly in the soil, where an anaero- period set in for a time.

In the dry season, when soil moisture fluctu- d between 29% and 31%, the rate of CO_2 olution from the litter surface did not fall cept in one case (January 25, 1960), which s most probably due to the negligible amount litter at the observation site. Far less CO_2 s liberated from the soil than in the wet sea- ı, this again probably being due to decreased crobiological activity.

The following values relating to the ever- en biogeocenosis show that CO_2 evolution not influenced by the amount of litter but ends on the season of the year.

nth and eason	Litter amount kg/ha	CO_2 amount kg/ha per hour	 kg/ha per month
r. (arid)	913.9	3.225	2,322.0
ɔ.(foggy)	517.1	3.445	2,480.4
y(rainy)	869.9	3.849	2,771.3

The maximum CO_2 evolution occured in August, when the litter amount was the same as in July, and rose to 4,798.1 kg/ha. Even when we allow for the tentative and approximate nature of such computations and discount the July values, it is obvious that in general the CO_2 production from the litter surface varies negligibly from month to month within a given season. This may be due to the small seasonal variation in the relative humidity of the air under the forest cover and to a levelling out of the litter decay conditions as a result of the narrow range of variation in litter moisture. The following are the parallel values for the bamboo biogeocenosis:

Month and Season	Litter Amount kg/ha	CO_2 Amount kg/ha per hour	 kg/ha per month
Mar.(arid)	1,620	2.497	1,797.8
Feb.(foggy)	772	2.054	1,478.9
July(rainy)	468	3.025	2,178.0

While the CO_2 production from the bamboo litter is on the whole low, the maximum occurs in the rainy season and the minimum in the foggy season; to some extent this phenomenon may be connected with the amount of litter. In the arid season, however, there is no such relationship and the CO_2 production is higher than in the foggy season, the amount of litter-fall being at its maximum and mineralization being more intensive. If we study the diurnal variation in the CO_2 evolution (Fig. 2) we find that in the evergreen biogeocenosis it is highest in the foggy season; at the beginning of the rainy season it falls slightly, to reach a minimum in the dry season. Comparing these values with those discussed previously we see that the rainy and foggy seasons vary from place to place. From other characteristics we note two diurnal peaks in CO_2 evolution: the first (highest) occurs in the arid and foggy seasons, at 13.00 h, the second (lower) at 21.00 h. In the rainy season there is one peak, this time at 17.00 h, because that is the time of day when heating of the litter surface under the forest canopy is greatest.

The amplitude of variations in CO_2 evolution during the 24-hour period is 1.662, 1.200 and 1.040 kg/ha per hour in the dry, foggy and rainy seasons, respectively.

For comparison, the rate of CO_2 evolution during the 24 hours of February 18, 1960 was determined in a clover field. The following are the values obtained for various hours of the day:

0100 h	1.736	kg/ha	per hour
0500 h	1.174	"	"
0900 h	1.808	"	"
1300 h	4.927	"	"
1700 h	4.289	"	"
2100 h	3.395	"	"

As we see, CO_2 evolution was higher in the open than under the forest cover and, secondly, the peak period continued longer (from 1300 to 2100 h), the spread amounting to 3.753 kg/ha. These values clearly indicate a predominance of organic residue mineralization in the open-field soil, whereas under the forest cover mineralization is slight even in the dry season.

The calculation of CO_2 evolution from these

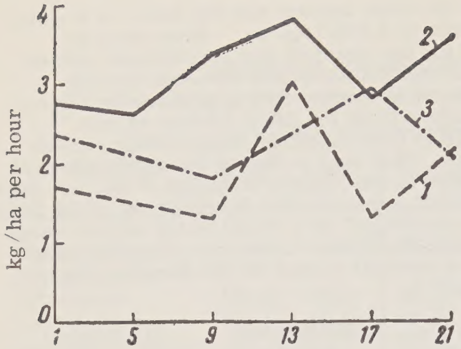


Fig. 2. - Diurnal variation in CO_2 evolution from litter surface under evergreen biogeocenosis (kg/ha per hour).

1 - March 18, 1959; 2 - February 18, 1960; 3 - May 24, 1959.

(by half) period during which decay of organic matter occurs.

It follows from this comparison that under tropical conditions the organic litter decays more slowly and its almost complete decompos tion is ensured only by the complete annual cyc of biochemical processes.

Variations in CO_2 Content of Soil Air

The main source from which the air of stron ly allitic tropical soils fills up with carbon dioxide is organic litter falling on the soil surface. The humus content in the soil is negligible and therefore cannot supplement the gas phase of the soils with carbon dioxide to any appreciable extent. The CO_2 formation by roots has been studied very little. Mina's values (3) for leached chernozems show that their part in CO_2 formation accounts for 33%-36% of the total amount of CO_2 entering the soil surface.

Table 5

CO_2 evolution in kilograms per hectare

Period	Evergreen forest			Opened area Feb. 18, 1960
	Foggy Feb. 18, 1960	Dry May 24, 1959	Rainy May 24, 1959	
Days	75	44	54	70
Month	2279	1323	1634	2114
Season	9077	2647	9806	—

values (Table 5) by day, month, and season was more accurate and gave the following values (rounded-off, Table 5).

Monthly CO_2 evolution varies over a fairly wide range, particularly in the rainy season. Allowing for its reaching 6.6 kg/ha per hour in particular months, we find that the seasonal amount of CO_2 evolved must have increased roughly twofold (i. e., up to 20,000 kg/ha) while the annual CO_2 production can amount to 32,000 kg/ha. Similar calculations for the forest steppe zone (Mokhovoye oak plantation) (3) gave the following results:

Period	June	July	September	
days	169	119	51	kg/ha
months	5,070	3,570	1,530	"

During the growing period the quantity of CO_2 evolved amounts to roughly 16,000 kg.[7] The diurnal and monthly amount of CO_2 evolved in the forest steppe was higher than in the wet tropical regions, but the annual production was only half as much, owing to the shorter

This value is a rough guide and cannot be taken as applying to tropical soils. Another probable source of CO_2 in the soil air is soil animals which evolves CO_2 in respiration. As we indicated previously, the most important of these are termites. No experimental data on CO_2 evolution, however, are known to us.

The CO_2 measurement was made by means of brass tubes 3-4 mm in diameter set in the soil at depths of 10, 20, 40, 60, 100, 150, and 200 cm. Samples of soil air were pumped out once a month.

It was established by investigation that the CO_2 intake by the soil under temperate zone forests depended mainly on the hydrothermal conditions. In the tropics hydrological conditions were more important (the intensity of rainfall and the manner in which the soils were wetted). Certain peculiarities in the physical properties of the soils, however, call for mention. These soils possess high porosity, varying from 60%-69% and from 57%-61% in the 2 meter layer of the evergreen and bamboo biogeocenoses, respectively, and a field moisture capacity in the same stratum varying from 32%-36% (volume percentages). With porosity so pronounced it is impossible for all the pores to be filled with water, even in periods of very intensive wet soils.

---

[7] CO_2 evolution for May, August, and October has been taken provisionally as 1,500, 3,570, and 800 kg/ha, respectively.

The influence of the soil thermal, regime is
t to a lesser extent; in other words it is
rly constant throughout the year. Tempera-
e differences at the soil surface and at depths
ow 60-100 cm remain considerable and
refore favorable conditions are created for
ow" of CO_2 down the soil profile and for its
gnation at depths below 100-150 cm.

This flow increases during the rainy season,
en part of the CO_2 may enter the lower hori-
ıs as a result of desorption from the porous
face as a result of displacement by soil mois-
e. This phenomenon can be clearly seen
m the distribution curves for CO_2 in the soils
particular seasons of the year (Fig. 3). The
$_2$ accumulation in the soils is greatest in the
ny season.

At 60 cm and deeper, the CO_2 accumulation
the soil shows a particularly marked increase.
the top 10-cm layer the amounts of CO_2 are
st, owing to excessive wetting of the soil.
s effect is more pronounced in the soil of
bamboo biogeocenosis, where the soil be-
nes wetter than in the evergreen biogeo-
ıosis.

In the dry and foggy seasons the CO_2 distribu-
ı along the soil profiles remains the same
in the rainy season, but the amount of CO_2
reases sharply, owing to the low CO_2 intake
m the litter, for in these seasons there is
igh degree of CO_2 return into the surface
er of the air. On the whole there is less
$_2$ accumulation in the soil of the evergreen
geocenosis and more in that of the bamboo.
s feature has been established also from
minimum and maximum values for CO_2 content at different depths. These vary as follows in the course of the year:

Depth cm	Evergreen Forest	Bamboo Forest
10	0-5.10	0.20- 3.50
20	0.40-4.60	0.60- 5.20
40	0.40-4.45	1.00- 7.40
100	1.40-5.80	2.20- 7.80
200	3.40-6.30	4.10-10.80

As we see, the basic pattern is kept in both soils: the amount of CO_2 increases with depth and its evolution is more intensive under bamboo than under evergreen. In the top 10 cm layer of the soil in the evergreen biogeocenosis the maximum CO_2 content can be higher than in the bamboo, but this does not increase its content in the deeper layers. The chronoisopleths in Figure 4, A and B, show how the CO_2 concentration in the soil air varies in a distinctly seasonal manner, mainly as a function of the amount of precipitation (Table 4) and the degree of soil wettness.

The latter is highest in the evergreen biogeocenosis from May to the middle of October (30%-46%). During the rest of the year the moisture content varies from 23%-30%. In the bamboo biogeocenosis the corresponding values are 36%-48% for soil moisture from May to December and 21%-39% for the rest of the year. Soil moisture in the bamboo biogeocenosis was higher throughout the year than in the evergreen.

Comparison of the content and the distribution of CO_2 in the soil air of the yellow earths (Fig. 5) with the elements of the hydrothermal soil regime and surface air layer of the evergreen

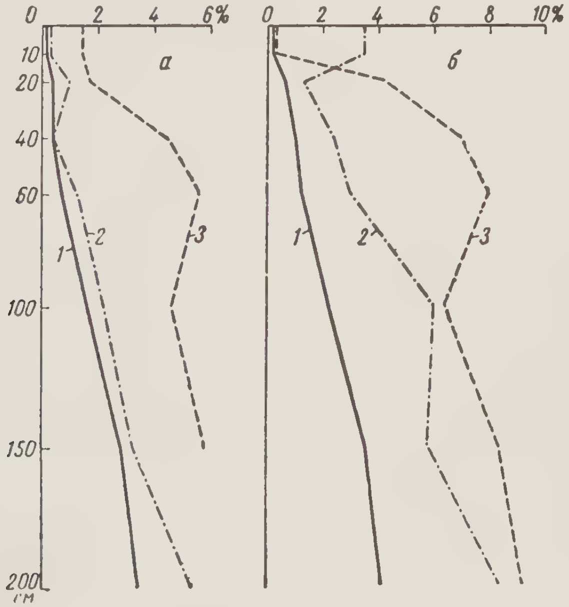


Fig. 3. - Distribution of CO_2 in soils by seasons of the year:

a - under evergreen; b - under bamboo. 1 - March 24--dry; 2 - September 26--foggy; 3 - August 24--rainy season.

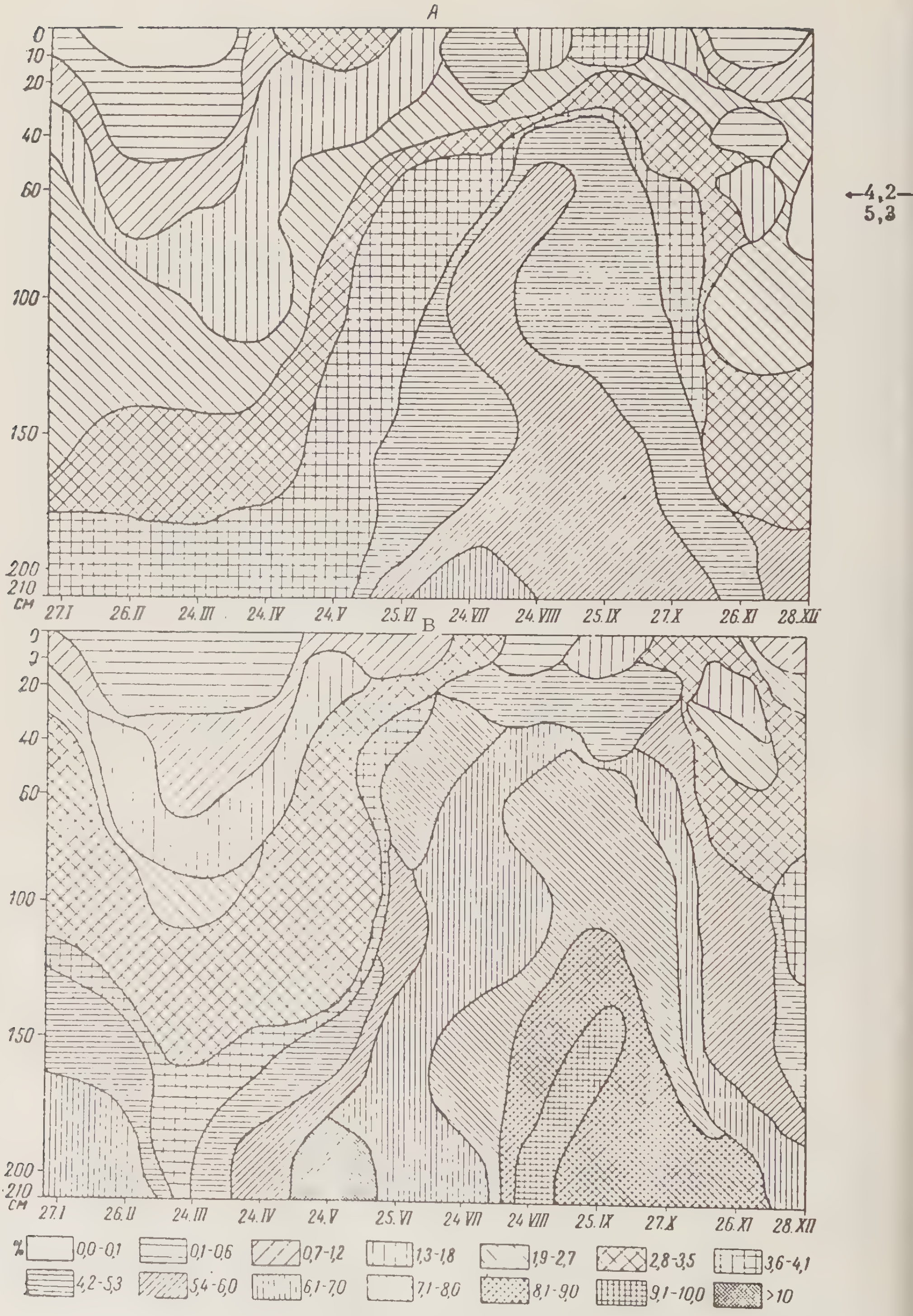


Fig. 4. - Chronoisopleths of CO_2 concentration in soil air of:
A - Evergreen forest yellow earth biogeocenosis; B - bamboo red earth biogeocenosis.

forest biogeocenosis shows a clear relationship in that:

1) the CO_2 content in the soil air is lowest during the dry and foggy seasons (from January

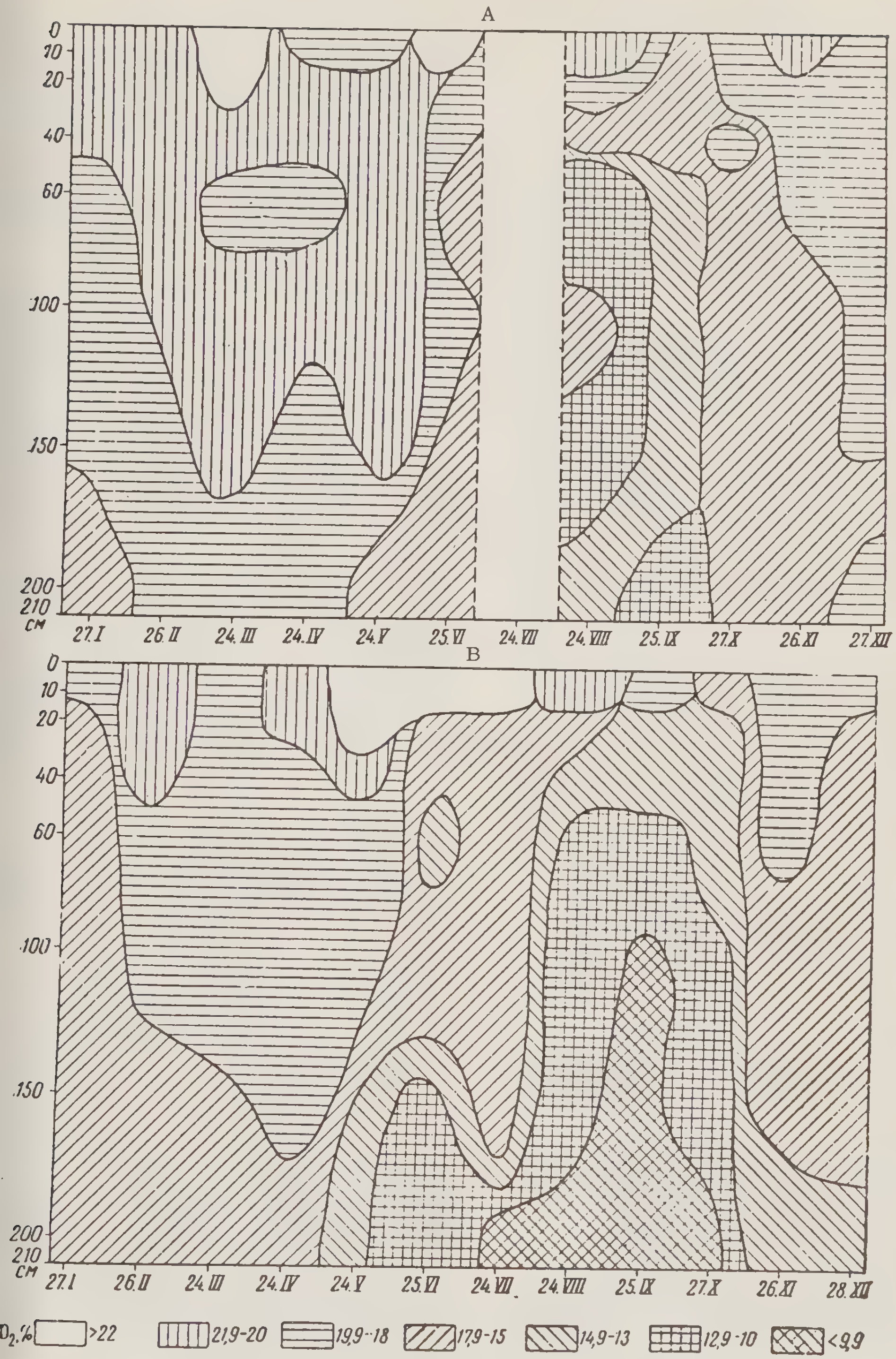


Fig. 5. - Chronoisopleths of O_2 concentration in soil air of:

A - Evergreen forest yellow earth biogeocenosis; B - bamboo red earth biogeocenosis.

pril) and gradually increases from 0%- with depth;

2) there is a very rapid increase in CO_2 content throughout the 2 meter layer, accompanied

by CO_2 accumulation with depth, during the wet season (from May to October); this increase at first spreads to the top (10-30 cm) layer and then as the soil becomes wetter, penetrates further down. Towards the middle of the wet season (July-August) CO_2 content in the soil air reaches a maximum at a depth of 200-210 cm;

3) with the end of the wet season and the sharp increase in moisture loss from evapotranspiration, the CO_2 content again gradually decreases to between 0.1% in the top and 5.3%-5.5% in the lower horizons;

4) the annual CO_2 accumulation in the soil air of the lower horizons is not completely resorbed or completely discharged through physical-chemical weathering processes; as a result, it remains constant at a level of 3.6%-4.0% below 180 cm throughout the dry period.

The CO_2 distribution in the soil air of the red earths under bamboo forest on the whole follows the same pattern as in the yellow earths; the differences can be summarized as follows:

1) throughout the year the CO_2 concentration in the soil air is higher than in the yellow earths;

2) during the dry season (January-April) the residual CO_2 concentration in the soil air below 10 cm is higher and does not fall below 4.6%;

3) in the wet season the CO_2 concentration is higher throughout the soil profile, showing a particular increase in May (up to 7%-10% at a depth of 170-200 cm); in the next period concentrations up to 6.5% start 40 cm down, increasing to 9.2% below this depth;

4) the reduction in CO_2 concentration from October onwards is more gradual than in the yellow earths and this effect is responsible for the higher residual content in the lower horizons during the rest of the dry and foggy seasons;

5) in the surface horizons (to a depth of 10-20 cm) the CO_2 concentration in the soil air is lower than in the yellow earths, probably because of a coarser texture and more rapid displacement of CO_2 in the lower lying horizons.

The fact that the curves for CO_2 concentration in the soil air of both soils show common features indicates that the data are reliable. The general abrupt increase in CO_2 concentration in the soil under bamboo does not give rise to any misgivings, but indicates intensive flow of CO_2 into the lower horizons accompanied by more intensive CO_2 production. Moreover, so high a concentration in the soil air of the lower horizons, as a result of a reduction in the oxygen content, determines the existence of regularly recurrent anaerobic periods. It is noteworthy that the curves for CO_2 concentration in the soil air of tropical soils have some features in common with similar leached chernozems under oak plantations (3): the zones of high CO_2 concentration in the soil air form at depths of 150-200 cm in the leached chernozems as well, during seasons of maximum litter decay and high moisture. These zones are, however, less pronounced and the CO_2 concentration does not exceed 2.1%-2.5%. These compar sons clearly show that under tropical conditions a considerable part of the CO_2 formed during litter decay, whether as a result of high relative air humidity or of intensive soil wetting during the rainy season, mainly enters the soil and is displaced by soil moisture into the lower horizons. In the rainy season pronounced CO_2 flow occurs. Another factor fostering heavy CO_2 accumulation in the soil air is that the soils possess high porosity. As a result, even in periods of maximum wetting, some of the pores in them are free and only the compositio of the soil air alters, in the direction of higher CO_2 concentration. The anaerobic character of tropical soils thus proves to be quite a pecul iar feature not as a result of a general lack of air but a low O_2 concentration in the air.

In the 2 meter layer of leached chernozems under oak plantation (3) the CO_2 content of the soil air was found to be 106 kg/ha in June. In the tropical soils it attains roughly the following values:

	Dry Season	Wet Season
Under evergreen forest	200-250	400-450 kg/ha
Under bamboo forest	300-350	500-550 "

Differences of this magnitude undoubtedly have a considerable and peculiar effect on the conversion of the mineral part of the soils and the processes of soil formation.

Variations in O_2 Content of Soil Air

The O_2 concentration in the soil air of the tropical forest biogeocenoses varies during the year within the following limits:

Depth, cm	Evergreen %	Bamboo %
10	16.0-24.8	16.8-28.9
20	16.9-24.3	14.3-23.9
40	11.4-21.3	13.2-20.0
60	12.4-21.0	11.6-19.8
100	14.5-22.0	9.7-19.2
150	11.3-23.0	8.6-19.0
200	12.8-19.0	7.8-17.2

The considerable variations in O_2 concentrations at all depths of the layer under study and the decrease in these variations with depth, pa ticularly in the soil under bamboo, are very typical. In the bamboo soil the O_2 concentration in the soil air at a depth of 200 cm decreas to 7.8%. In the evergreen, the lower limit is 11.3%. In the bamboo the O_2 deficit in the soil air is a good deal higher and may affect a soil thickness from 20 to 200 cm or more. In the evergreen soil we find a similar boundary at a depth of 40 cm. In the soil air under broadleaf forests in the European part of the USSR; so the O_2 deficit in the air of the tropical soils is exceedingly pronounced. If we assume that wit an O_2 content of less than 15% in the soil air th is a change in the ratio of aerobic and anaerobi processes, such changes will be much more marked and intensive in the tropical soils than

soils under a temperate-warm continental
mate. In the latter an O_2 content of less than
% is observed when the moisture content ex-
ds the field moisture capacity and signs of
erobic processes appear externally in the
m of patches of gleyzation. In tropical soils
O_2 concentration of less than 9% corresponds to
oisture content lower than field moisture
acity and no signs of gleyzation are detected
he soils. Where porosity is high the reduced
concentration is due to increased O_2 loss
ough biochemical processes and respiration
soil animals.

It can be assumed that the anaerobic condi-
ns in tropical soils are due not to excess mois-
e but to oxygen deficiency in the soil air.
of the main peculiarities from energetics
cesses is that the soil formation under these
ditions develop in the course of alternation
wo very pronounced gas regimes: an oxygen
ime in the dry and foggy seasons and a car-
dioxide regime in the rainy season. This
be seen from the graphs for O_2 distribution
he soil air throughout the year (Fig. 5 A and

In the soil under evergreen biogeocenosis the
content in the soil air is highest in the top
izons (24%-30%) from January to May; it
reases to 17%-15% with depth. In this sea-
the O_2 content in the top 10-15 cm layer
observed to decrease to 18% only on rainy
s. With the onset of the rainy season the O_2
centration decreased to 20%-15% in the top
cm and to 12.9%-10.0% below that level; only
m the end of October was there a gradual in-
ase, to 18%-19%.

The same picture is repeated in the bamboo
l but with a more pronounced oxygen deficiency.
ing the rainy season the oxygen content below
cm decreases to 12.9%-10%, whereas below
cm it decreased as far as 9.7%-7.8% in the
iod from July 27 to October 27. The O_2
centration also decreased in the dry season
varied between 19% and 15%.

The period of lowest O_2 content occurs later
n in the evergreen biogeocenosis. When there
ntensive rainfall, however, the O_2 content
he soil air of the upper 10-15 cm is constant
20%-28% — a higher level than in the ever-
en biogeocenosis. This might be due to a
rser texture in this layer; but the low oxygen
ke in the lower horizons can be accounted
by oxygen loss to decomposition of the bam-
litter.

The data obtained are not dubious even though
ne of the values for O_2 distribution spoil the
ularity of the picture; the variation in O_2 con-
t is corroborated not only by the regular sea-
al variation of O_2 content in the soil air but
by the interrelationship between these
nges and the CO_2 variations.

Conclusions

The biological energetics of the soils in the
est biogeocenoses can be taken, by way of
rst approximation, to be made up of two
n processes: a) the production of free CO_2
m energetic materials reaching the soil surface and, b) the migration of the CO_2 so formed into the surface air layer and into the soil.

Although these processes are interrelated they can vary in character and intensity. This is particularly true of the migration process, which depends less on the amount of CO_2 produced and more on the hydrothermal conditions of the surface air layer and the soils, as well as on the properties of the latter.

The evergreen biogeocenosis is characterized by a higher energy of soil-biological processes than the bamboo. This is understandable if we take into account the structural complexity of the former and the structural simplicity — homogeneity — of the latter, together with the difference in hydrothermal conditions created in the two different canopies. The migration processes are more complicated to evaluate. In some cases an upward migration into the atmospheric air may predominate, in others a downward migration into the soil. As we have no direct data from which to find the direction of migration, our only way of knowing it is indirectly, from the amount of CO_2 entering the soil. It can be assumed that under tropical conditions downward migration, at varying rates, predominate. This depends not only on the factors enumerated previously but also on the composition and properties of the soils. These, however, undergo continuous and substantial alteration, depending on the character and intensity of their CO_2 uptake, and so the character of the CO_2 entry and the rate of its concentration in the soil air can be used as an index to the energetics of the biochemical processes in the soils. When there is a predominance of O_2 in the composition of the soil air, these processes have an aerobic character; in the opposite case they will have an anaerobic character. The boundary between the two can be set at a CO_2 concentration of 15% in the soil air.

It follows from these assumptions that soil formation under the evergreen biogeocenosis takes place through the greater part of the year under aerobic conditions, whereas in the bamboo biogeocenosis it takes place under anaerobic conditions, with excess CO_2 in the soil air. As a result there is greater gleyzation of the layer in which the CO_2 accumulates in the bamboo biogeocenosis along with a higher pH, a lower exchangeable H content, and greater allitization of the mineral mass. It should be emphasized that the intensification of the latter process is not bound up with the other properties of the soil, so we are entitled to assume that it is residual in character and took place before the bamboo was planted. This question, however, calls for further study.

There is important scientific and practical value in the establishment of such substantial differences between the soil energetics in the two types of tropical forest biogeocenoses; this reveals the essence of the biochemical processes and the difference in the character and trend of soil formation connected with them.

While conversion of the mineral part of tropical soils is relatively monotypic in the direction of allitization and lateritization, the biological processes in these soils develop differently and depend on the composition of the vegetation interacting most deeply with the soil and determining the differences in the energetics of soil formation. Further study of these interactions and particularly of their energetics aspect will undoubtedly tell us a great deal more about the genesis of tropical soils. It should be noted that the excess accumulation of CO_2 in the soil air under bamboo and the reduced O_2 content is a negative factor, altering the energetics of the biological processes in these soils.

Received September 5, 1960

BIBLIOGRAPHY

1. VOLOBUYEV, V. R. 1958. Some aspects of the energetics of soil formation. Pochvovedeniye, No. 7.

2. ZONN, S. V. 1954. The influence of forest on soil. USSR Acad. Sci. Press, Mosco

3. MINA, V. N. 1960. The rate of carbon-dioxide formation and its distribution in the soil air of leached chernozems, in relation to the composition of the forest vegetation. Trans. Forestry Labor., USS Acad. Sci. Vol. I.

4. SUKACHEV, V. N. 1947. Fundamentals of biogeocenology theory. Jubilee collection for 30th anniversary of October Revolution. USSR Acad. Sci. Press.

5. ZONN, S. V. 1960. Der Einfluss des Waldes auf die Böden. Veb. Gustav Fischer Verlag, Jena, (enlarged edition).

OME FEATURES OF HUMUS FORMATION IN MOUNTAIN SOILS
F NORTHERN TYAN'-SHAN'

A. ASSING, Institute of Soil Science, Kazakh Academy of Sciences

In mountainous countries we are confronted
h an aggregation of peculiar topographical
tures and biocenoses which do not occur in
vlands. Within each vertical zone one can
serve a sharp differentiation of the topography
the slopes of various exposures, particularly
high mountain regions.

Although a great deal of information has now
en accumulated in regard to the humus com-
sition of particular mountain soils, the geo-
aphical patterns of humus formation in moun-
nous countries has been studied very little.
r investigations relate to the mountain soils
the Transilian Ala-Tau and the Ketmen
nge, which are the northernmost chains of the
an'-Shan'.

A typical feature of the Northern Tyan'-Shan'
the large part played by mesophilic meadow
noses in its vegetation; these, together with
ests of Schrenk spruce (Picea Schrenkiana)
m a pronounced forest-meadow belt.

Data on the structure of the vertical belt
mation at high-altitude boundaries of the
rthern Tyan'-Shan' topographical belts are
eady available in the works of those who first
estigated this mountain country: Prasolov
, Bezsonov (2), and Abolin (1). The high-
itude boundaries of certain vertical zones
re later delineated more precisely by
kolov (7), Bogatyrev (3), and Glazovskaya
5), and described in greater detail. Here
following alternation of soil-vegetation belts
zones can be observed:

I. A perpetual snow, glacier and rock zone
absolute altitudes above 3,800 - 3,400 m.

I. An alpine and sub-alpine mountain-
adow and high mountain-meadow steppe zone
m 3,800 - 3,400 to 2,800 - 2,700 m.

I. A spruce-forest, tall-grass meadow, and
ub steppe zone on mountain forest dark non-
dzolized or deeply podzolized soils and
untain steppe soils from 2,800 - 2,700 to
00 m.

IV. A deciduous forest zone with meadow-
ppe lands of miscellaneous grasses on grey
est podzolized soils and leached chernozems
m 1,700 to 1,400-1,200 m.

V. A steppe zone of feather and motley grasses or feather and sheep's fescue on mountain ordinary chernozems and dark chestnut soils from 1,400 - 1,200 to 850 - 800 m.

VI. A desert steppe zone of sheep's fescue with wormwood and wormwood with ephemeroids on light chestnut soils and ordinary sierozems from 850 to 800 to 650 m.

VII. A wormwood-thistle desert on light and grey-brown sierozems below 650 m.

Humus Content and Composition in the Mountain Soils

We shall start our examination of the data on organic matter in mountain soils with the mountain-meadow soils formed, in the peculiar climatic conditions of high altitudes, under dwarf alpine and tall grass sub-alpine meadows with mixed grasses. Moisture in the high mountain-meadow zone is high, mean annual precipitation being 730-750 mm.

As regards their principal genetic signs, mountain-meadow soils are shallow, heavily sodded, skeletal, well-structured, and have a high humus content. The exchangeable cation content varies from 25 to 45 meq. The difference between mountain-meadow alpine and subalpine soils is that the former are shallower and contains fewer exchangeable cations. The humus content and composition in both soils are shown in Table 1. Tyurin's system has been used for the humus composition analysis.

As Table 1 shows, mountain-meadow soils have a high humus content (up to 20%) and contain large amounts of free humic substances, particularly fulvic acids (fraction I). Although the humus content is high, fulvic acids predominate in the composition of the humus, rather than humic acids as in the case of chernozems, the most humic soils. These mountain-meadow soils approximate to the highly humic chernozems in total humus content but are nearer to the northern forest soils as regards humus composition. The former of these two features seems to be connected with the rich meadow vegetation and particularly with the presence of a thick, fine gramineous root system; the humus composition, on the other hand, appears to be due to the hydrothermal conditions

Table 1

Humus composition and exchangeable cation content[a]

Soil and location	Depth, cm	Humus (Tyurin method), %	N, %	C : N	Humic acids				Fulvic acids					Non-hydrolyzable residue	Humic acid C / Fulvic acid C	Exchangeable cations, meq/100 g		
					Fractions													
					I	II	III	Total	Ia	I	II	III	Total			Ca	Mg	H
Alpine mountain-meadow, Transilian Ala-Tau, talgar pass, Abs. altitude 3,280 m.	0—12	14,87	Not det'd.		9,34	13,43	1,86	24,64	3,32	21,31	1,45	2,18	28,26	38,38	0,87	22,17	5,65	4,56
Alpine mountain-meadow, northern slopes of Transilian Ala-Tau. Turgen River source. Abs.alt. 3,200 m	0—15	17,30	1,02	9,8	8,22	20,81	2,06	31,06	3,09	26,93	3,98	1,21	35,21	28,44	0,88	21,60	3,46	4,45
Subalpine mountain-meadow, northern slopes of Transilian Ala-Tau. Abs. altitude 2,860 m.	0—10	14,36	Not det'd.		12,54	9,67	3,58	25,79	—	11,23	21,80	1,91	34,94	33,69	0,74	27,8	6,35	1,11
Subalpine mountain-meadow, northern slopes of Ketmen range. Absolute altitude 2,900 m.	0—10	20,98	0,94	11,5	6,91	13,93	2,88	23,70	3,12	16,26	8,48	0,91	28,77	44,83	0,82	36,28	9,3	1,1
Dark non-podzolized mountain-forest, northern slopes of Transilian Ala-Tau. Abs. alt. 1,750 m.	15—20	12,78	—	—	1,70	20,20	4,00	25,90	3,89	3,26	27,78	4,01	38,10	28,20	0,61	58,0	3,48	
Dark grey mountain-forest, northern slopes of Transilian Ala-Tau. Abs. altitude 1,400 m.	0—10	14,0	—	—	17,91	8,96	7,06	33,93	—	6,50	30,0	2,82	39,32	28,95	0,86	38,20	8,06	1,0

---

[a] In this and the following tables the carbon content of the individual groups of humic substances is given in percentages of the total carbon in the original soil.

Note: Comma represents decimal point.

Table 2

Humus content of mountain leached chernozems

Location	Humus (Tyurin method), %	Humic acids				Fulvic acids					Non-hydrolyzable residue	Humic acid C / Fulvic acid C
		Fractions										
		I	II	III	Total	Ia	I	II	III	Total		
Northern slope of Transilian Ala-Tau. Absolute altitude 1600 m.	12,64	6,48	22,35	1,74	30,57	2,74	5,71	16,58	0,97	26,0	35,40	1,2
Northern slope of Ketmen range. Absolute altitude 1,800 m.	9,60	12,18	17,20	3,58	32,96	—	9,14	10,57	2,0	21,66	35,40	1,5

Note: Comma represents decimal point.

the high mountain zone (continuously wet with
w temperatures throughout the year).

Below the subalpine meadows, on the north-
n exposure of the slopes, extend forests of
hrenk spruce, under which peculiar mountain-
rest dark non-podzolized or deeply podzolized
ils form. The top horizon of these soils is
ually heavily turfed, with a downward transi-
n to a humic horizon of dark cinnamon-brown
lor and powdery-granular structure. Podzoli-
tion is prevented by the richness of the
hrenk spruce litter-fall in calcium and the
epness of the slopes on which the mountain-
rest soils form. Despite the large amount of
ecipitation falling in this mountain-forest
ne (840-880 mm), signs of podzolization ap-
ar only in the soils developed on lower,
re gently sloping fine earth portions of the
pes. Below the spruce forests, where the
lief is less disjointed and consists of gentle
pes and the tops of ridges made up of loess-
e clay loams, mountain-forest, dark grey,
dzolized soils form under aspen forests.
ble 1 shows the humus composition of these
untain-forest soils.

The spruce and deciduous forest soils are
y rich in organic matter. Humus content in
top horizons of the mountain-forest dark
ls under spruce amounts to 8%-12%; in the
k grey forest soils it is even higher - 14%
more (up to 18%). Both types of forest,
ticularly the deciduous, have a well developed
ss cover (gramineae, forest motley grasses).
e exchangeable complex of these soils is
urated with calcium. The dark grey pod-
ized soils contain small amounts of ad-
bed hydrogen and have a characteristically
her content in free humic acids than the
untain-forest dark soils. The latter have a
rower humic acid to fulvic acid ratio but
distinguished as to humus composition from
spruce forest soils of the podzolic zone by
onsiderable (relative and absolute)humic
d content, as a result of calcium (fraction

In the deciduous forest subzone mountain leached chernozems form under motley grass-gramineous vegetation in which forest species (Ligularia) is included in places free of forest.

Unlike the forest soils, these soils have a humus composition in which humic acids predominate (Table 2). The humic to fulvic acid ratio in the mountain leached chernozems is invariably greater than unity. Among the humic acids the fraction bonded to calcium predominates but there is a fairly high content in free humic and fulvic acids.

The lower foothills of the Transilian Ala-Tau, the Ketmen range and other ranges of the Northern Tyan'-Shan' are covered with feather-motley grass and feather-sheep's fescue steppes on mountain ordinary chernozems and mountain dark chestnut soils.

Annual precipitation averages 460-500 mm in the mountain-steppe zone. The foothills are composed mainly of loess-like clay loams but sometimes there are also compact bedrock with shallow soils containing detritus.

The mountain foothill chernozems have a characteristically fairly thick humus horizon (70-80 cm) of pronounced granular structure, with carbonate precipitations in the form of patches in the lower part of the humus horizon; as regards humus content they belong to the medium- and low-humus chernozems. A little lower are dark chestnut soils, distinguished from the low-humus chernozems by having a humus horizon of cinnamon-brown tint and by the fact that they are shallower (not deeper than 45-55 cm) and have a much poorer blocky-silty structure. These soils differ little from one another as regards humus composition (Table 3). The humic to fulvic acid ratio is slightly higher than unity (1.1-1.2), increasing to 1.3 in the more humic chernozems. There is a marked predominance among humic acids of those which are bonded to calcium, a typical feature of steppe-type soil formation. The fulvic acids do not

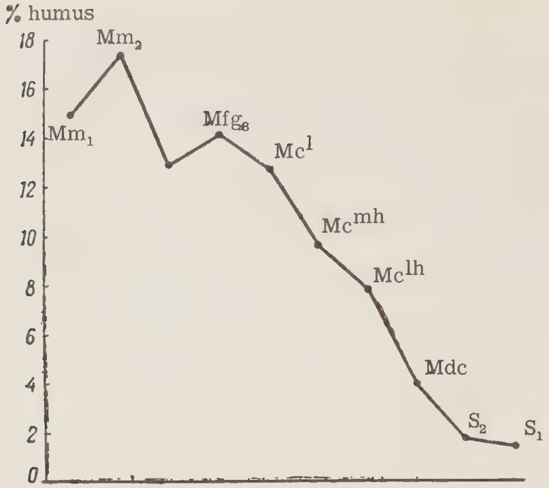


Fig. 1. - Humus content in mountain soils.

Soils: Mm_1 - Alpine mountain-meadow; Mm_2 - Subalpine mountain-meadow; Mf - Mountain-forest, dark; Mfg_3 - Dark grey mountain-forest; Mc^l - mountain leached chernozems; Mc^{mh} - medium humus mountain ordinary chernozems; Mc^{lh} - low humus mountain ordinary chernozems; Mdc - mountain dark chestnut soils; S_2 - foothill dark sierozem; S_1 - foothill light sierozem.

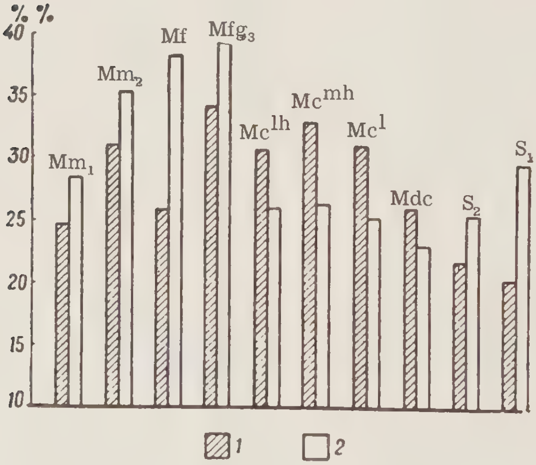


Fig. 2. - Humic to fulvic acid ratio in mountain soils (% of total C).

1 - humic acids; 2 - fulvic acids

start to dominate again until the transition to the desert-steppe and particularly the desert zone is reached.

Annual precipitation in the foothill belt is 250-200 mm in the upper part and about 150 mm in the lower part.

In the upper part of the foothill plain dark sierozems form under wormwood-ephemeroid vegetation on loess-like clay loams; in the lower part the sierozems are lighter in color and usually of coarser texture. The sierozems of the Northern Tyan'-Shan' foothill plains belong to the low-carbonate type, the CO_2 content the top horizon being not more than 1.5%-2.5%.

A porous encrustation, several centimeters thick and of light grey color and scaly-stratifie structure, can be clearly distinguished in the dark sierozems. The humus horizon is 26-30 cm thick; in the light sierozems it is a good dea shallower (18-22 cm). In both sierozems there is a clearly defined illuvial carbonate horizon

Humus composition and exchangeable cation content in soils of the mountain-steppe zone

Soil and location	Depth, cm	Humus (Tyurin meth-od, %)	N, %	C:N	Humic acids				Fulvic acids					Humic acid C / Fulvic acid C	Non-hydrolyz-able residue	Exchange-able cations, meq/100 g	
					Fractions												
					I	II	III	Total	Ia	I	II	III	Total			Ca	Mg
Mountain ordinary chernozem. Foothills of Transilian Ala-Tau. Abs. alt. 1,200 m.	1–13	9.53	0.61	9.1	5.76	25.03	3.11	33.89	4.42	7.56	12.15	1.99	26.12	1.3	36.0	31.96	3.75
Mountain ordinary chernozem. Foothills of Ketmen range. Abs. alt. 1,380 m.	0–10	7.84	Not det'd.		8.97	19.36	2.61	30.94	—	9.82	12.71	2.77	25.30	1.2	37.80	—	—
Dark chestnut mountain soil. Lower rolling foothills of Transilian Ala-Tau. Abs. alt. 960 m.	0–10	4.0	0.27	8.6	8.0	15.76	2.12	25.88	—	8.35	12.76	2.26	23.37	1.1	—	28.69	3.35

Table 4

Humus composition of foothill sierozems

Soil and location	Depth, cm	Humus (Tyurin meth-od, %)	N, %	C:N	Humic acids				Fulvic acids				Humic acid C / Fulvic acid C	Non-hy-drolyz-able residue
					Fractions									
					I	II	III	Total	I	II	III	Total		
Dark sierozem. Foothill plain of Transilian Ala-Tau	0–8	1.63	0.13	7.3	4.83	14.60	2.47	21.90	9.00	14.74	1.93	25.67	0.85	45.47
Light sierozem	0–6	1.39	0.12	6.8	2.92	13.94	3.57	20.43	7.15	17.88	4.47	29.50	0.69	43.03

starting at depths of 52-60 to 110-118 cm. The humus composition of the sierozems is shown in Table 4. Both in the dark and in the light sierozems fulvic acids predominate over humic acids, the light sierozems being characterized by a narrower humic to fulvic acid ratio.

Both the dark and the light sierozems have a characteristically high non-hydrolyzable residue content. The humus composition, then, changes abruptly, with the transition from mountain-steppe to foothill desert-steppe soil zone, in the direction of higher fulvic acid and non-hydrolyzable residue content.

The foregoing material discussed is shown graphically in Figures 1 and 2.

Conclusions

1. There is a gradual increase of humus content in the soil, from the foothill desert light sierozems to the high mountain alpine meadow soils. The mountain meadow soils are distinguished by a particularly high humus content.

2. Unlike lowland soils, mountain soils do not undergo a reduction in humus content in passing from mountain chernozems to mountain-forest and on to mountain-meadow soils, as in the northern taiga soils; the humus content remains as high as in the highly humic chernozems or even increases.

3. On transition from mountain chernozems to mountain-forest and mountain-meadow soils the humic to fulvic acid ratio changes in favor of the fulvic acids and at the same time the humus and humic acid content remains high; the latter feature is not observed in lowland soils.

Received April 12, 1960

BIBLIOGRAPHY

1. ABOLIN, R.I. 1930. From the Cis-Balkhas steppes to the snowy summits of Khantengri. Tr. In-ta pochv i geobot. Sredne-Az. gos. un-ta, pochv. 5. Kazakhstanskaya seriya. Izv. Narkomzema KazSSR (Alma-Ata) i In-t pochv. SAGU (Tashkent). Leningrad,

2. BEZSONOV, A.I. 1910. Soils of parts of th Dzharkentsk and Vernensk districts of the Semirechensk province. Tr. pochv.-botanich. eksp., part 1, St. Petersburg.

3. BOGATYREV, K.P. 1948. Study of high mountain soils of the Transilian Ala-Tau. Probl. sov. pochv., No. 12.

4. GLAZOVSKAYA, M.A. 1946. Material for the classification of soils on the northern slopes of the Transilian Ala-Tau. Izv. Akad. Nauk KazSSR, seriya pochv., vyp. 3(28).

5. GLAZOVSKAYA, M.A. 1949. Soils of the mountain regions of Kazakhstan. Izv. Akad. Nauk KazSSR, seriya pochv., vyp. 4(52).

6. PRASOLOV, L.I. 1901. Study of vertical soil zones in the Tyan'-Shan'. Pochvovedeniye, Vol. 1.

7. SOKOLOV, S.I. 1946. Tabulation of soils on the mountain part of the Malaya Almaatinka River. Izv. Akad. Nauk Kaz SSR, seriya pochv., vyp. 3(28).

8. TYURIN, I.V. 1949. Geographical patterns of humus formation. Tr. yub. sessii, posvyashch. 100-letiyu so dnya rozhdeniya V. V. Dokuchayeva. Akad. Nauk SSSR.

HYSICAL PROPERTIES OF COMPACT CHERNOZEMS

. S. BLAZHNIY and YU. N. BAGROV, Kuban Agricultural Institute

The compact chernozems bordering the northn foothills of the Northwest Caucasus have racted the attention of many investigators 2, 3, 4, 6, 7, 8, 14, 16 etc.) who indicate that e extremely unfavorable physical properties these soils greatly detract from their produce value.

There has not been any thorough and exhause study of the physical properties of compact ernozems. We shall cite some of the data tained from studies in the Transkuban footl plain. These data reveal the peculiarity physical properties in these soils and show t some methods that are widely employed other soils must be adapted for study.

One of the most important features of comct chernozems is their extreme fine textured il (Table 1). The physical clay content).01 mm in diameter) in all horizons exeds 70%, while the clay fraction is greater n 49%. In the compacted B_1 horizon, partis with these dimensions account for 80.7% d 60.2%, respectively. Clay particles preminate in the separates, followed by silt d then sand.

The high clay content, especially in the npacted B_1 horizon, clearly distinguishes se soils from other chernozems in Western anscaucasia, in which it rarely exceeds 40%.

In addition to the fine texture of compact ernozems, their microaggregates are of water stability, especially in the most npacted part of the profile (B_1 horizon), in which dispersion factor by Kachinskiy's method ches 30.4 (Table 1). All this leads to a rked change in the soil structure from sean to season. In late winter and spring they ell greatly and split into large clods 25-30 in diameter, separated by vertical cks 3-8 cm wide.

In view of these features, bulk densities re determined for each season. Three nples were taken on each plot in containers 200 cm^3 capacity. Table 2 gives the values an extremely dry autumn and a wet spring. ey show an inverse ratio between bulk sity and soil moisture. Thus, on a virgin t and on winter wheat stubble, soil moisture ied between 15% and 21% within the profile he autumn of 1955, while bulk density varied between 1.22 and 1.38 in A_1-A_2 horizons and 1.59-1.63 in the underlying horizons. In the spring, in March 1956, soil moisture reached field water capacity (29%-38%) on both plots, while the bulk densities were considerably lower than in the autumn plowed plot (0.97-1.10 in A_1-A_2 horizons, and 1.35-1.57 in horizons B_1, B_2, and BC).

The difference between layers was most marked when the moisture difference was highest. In the surface layers the moisture difference was 17.1%-23.5%, and at a depth of 235-240 cm it was only 5.6%-5.7%. The corresponding value for the bulk density was less by 0.25-0.34 in the spring in the A_1 horizon but only 0.05-0.06 in the C_2 horizon, which clearly confirms the existence of the inverse ratio. This dependency was also noted by Tyuremnov (15), when he studied the water-physical properties of Kuban leached chernozems.

The following conclusion can be drawn from the foregoing information on seasonal variation in the density of compact chernozems in relation to differences in soil moisture.

Bulk density figures obtained during dry periods when the profile of compact chernozems is split by wide cracks cannot be used to calculate total soil porosity, the total water content in the soil, or for other calculations, since the considerable volume of the cracks cannot be allowed for correctly when determining the bulk density of the soil by existing methods. Therefore, calculations of this type, for the soil as a whole, must be made from bulk densities obtained when soil moisture is close to field capacity, and when the soil profile is continuous and not cracked. The bulk densities of the various aggregates >3 mm in diameter were determined from samples containing hydroscopic water, and the figures portray their maximum value in compact chernozems.

Table 3 gives values for particle density and total and aggregate porosity. Particle density was determined by three measurements with a pycnometer. The value increases with depth from 2.66 to 2.81 and there is a parallel decrease in the amount of humus and increase in iron content (ore grains).

Total soil porosity, which reaches 64.7% in the A_1 horizon, falls sharply in the B_1 horizon

Table 1

Particle and microaggregate size analysis of compact chernozem in percentages of absolutely dry soil

Horizon	Depth, cm	Diameters, mm — of particles — analysis: 1—0,05	0,05—0,001	<0,001	Total <0,01	of microaggregates — analysis: 1—0,05	0,05—0,001	<0,001	<0,01	Dispersion factor
A_1	0—10	6,9	43,4	49,7	72,2	31,0	63,7	5,3	28,3	10,6
A_2	23—30	5,8	39,3	54,9	74,4	25,5	65,9	8,6	37,2	15,6
B_1	60—70	3,4	36,4	60,2	80,7	25,0	56,2	18,8	44,9	30,4
B_2	120—130	4,6	36,9	58,5	77,7	17,3	69,2	13,5	48,5	23,1
BC	160—168	6,3	36,5	57,2	77,7	25,3	66,4	8,3	32,0	14,5
C_2	230—240	5,2	39,9	54,9	78,9	23,2	74,6	2,2	37,2	4,0

Note: Comma represents decimal point.

Table 2

Data for moisture and bulk density determinations

Horizon	Depth, cm	November 1, 1955 — Virgin soil — Moisture, %	Bulk density	November 1, 1955 — Winter wheat stubble — Moisture, %	Bulk density	March 25, 1956 — Virgin soil — Moisture, %	Bulk density	March 25, 1956 — Fall plowed — Moisture, %	Bulk density	Bulk density of 3-10 mm diameter aggregates
A_1	2—7	20,9	1,22	14,9	1,28	38,0	0,97	38,4	0,94	1,55
A_2	23—28	19,3	1,35	18,4	1,38	36,9	1,10	37,5	1,08	1,68
B_1	60—65	19,7	1,62	19,7	1,63	34,2	1,36	35,2	1,35	1,73
B_2	120—125	19,3	1,60	20,2	1,61	28,2	1,43	29,5	1,42	1,76
BC	160—168	19,1	1,60	19,7	1,59	26,1	1,50	27,3	1,47	1,80
C_2	235—240	18,0	1,62	18,8	1,60	23,7	1,57	24,4	1,54	1,84

Note: Comma represents decimal point.

Table 3

Total and aggregate porosity

Horizon	Depth, cm	Bulk density at near FMC, g/cm³	Particle density	Total porosity[a]	Porosity of aggregates	Aggregate porosity	Aggregate porosity as a % of total porosity
				In percentages			
A_1	2—7	0,94	2,66	64,7	40,8	24,30	37,7
A_2	23—28	1,08	2,75	60,73	36,31	24,38	36,85
B_1	60—65	1,35	2,80	51,8	33,6	24,37	47,05
B_2	120—125	1,42	2,81	49,47	33,66	25,63	51,80
BC	160—168	1,47	2,81	47,69	32,65	25,51	53,49
C_2	235—240	1,54	2,81	45,20	32,01	26,09	57,72

---

[a] When soil moisture is close to the wilting content, the porosity of the clods decreases to 42-43% in the compact horizon.

Note: Comma represents decimal point.

51.8%). The decline is less abrupt further wn and reaches 45.2% in the C_2 horizon. e sharp decrease in total porosity in the mpact horizon, despite the increased clay ntent in it, is due both to its lack of struc- 'e and to its high compaction.

Determination of the porosity of the aggre- tes by Kachinskiy's method (10) shows that amount of internal porosity of the aggre- tes is extremely low. It is 40.8% at 2-7 cm, .6% in the 60-65 cm layer, and 32% between 5 and 240 cm. Kachinskiy found that the rosity of the aggregates was 50% and above the thick coarse clay loam chernozem of Kuban Oblast', and between 29% and 38% solonetzes. Thus the porosity of the aggre- tes of compact chernozems approaches that solonetzes, since the particles in the aggre- tes are packed very closely, as in a solonetz.

Aggregate porosity also comes close to t of solonetzes as determined by Kachinskiy's mula. Its absolute value increases slowly h depth from 24.3% in the A_1 horizon to 26.1% the C_2 horizon and remains extremely low in genetic horizons. The aggregate porosity a percentage of total porosity increases with oth from 37.6% (A_1 horizon) to 57.7% (C_2 rizon).

The unsatisfactory total porosity in the com- ct and lower-lying horizons, and the extremely porosity of the aggregates and aggregate rosity lead to water and air regimes in these ls that are most unfavorable to plant growth. ta on various forms of water in compact cher- zems are given in Table 4. Maximum hygro- opicity (MH) is very high, reaching 14.2% the A_1 horizon and 16.8% in the B_1 horizon, ich has a higher clay content and is more mpact.[1]

Maximum molecular water capacity, as ermined by Lebedev's method, has the same ationship to the clay distribution in the soil ofile: its value increases from 17.5% in the horizon to 19.3% in the B_1 horizon.[2] Note t in the leached chernozems of the Kuban, ich are finer in texture than the compact ernozems, maximum hygroscopicity and ximum molecular water capacity are cor- spondingly lower by 5%-3%.

The wilting moisture (WM) was determined 5 replications of the seedling method (5, 11). ur germinated winter wheat grains (Novou- inka 84) were planted in each container with neral fertilizers and soil taken from the B_1 rizon and below. Wilting became pronounced the 20th-25th day after the top of the con- ner had been sealed with paraffin. The ter content at this time, i. e., the value of the WM (Table 4), increased from 21.3% in the A_1 horizon to 23.4% in the B_1 horizon, and decreased to 19% in the C_2 horizon. In leached chernozems it does not exceed 16.1%.

The high WM in the A_1 and especially in the B_1 and B_2 horizons of compact chernozems is evidently due to the fact that the soil colloids are highly hydrophilic and that the soil particles are quite densely packed in the aggregates, greatly increasing the number of micropores and microcapillaries, the water which is in part non-available to plants owing to its poor mobility.

When determining WM, the plants finally die between the 5th and 15th day after severe wilting has started. Soil moisture at this time is 3%-5% less than during severe wilting, being 17.1% in the A_1 horizon, 18.4% in the A_1 horizon, 18.4% in the A_2 horizon, 21.0% in B_1, 19.3% in B_2, 17.6% in BC, and 16.8% in C_2.

The WM/MH ratio does not remain constant throughout the horizons, as can be seen from Table 4. In the upper part of the profile it is 1.5, i. e., the same as Kachinskiy's recommended calculated coefficient (10), while in the center and lower part of the profile it is closer to the coefficient 1.34 recommended by the Agricultural Weather Service.

The wilting moisture, calculated as a percentage of field moisture capacity (FMC), is as follows in these soils: A_1 horizon-53%, B_1 horizon — 64.8%, and C_2 Horizon — up to 75%. The values for the same horizons in the leached chernozems of Western Ciscaucasia are 51.9%, 59.7% and 66.3% correspondingly (12), while in ordinary terraced chernozems they do not exceed 40%-50% (11).

Thus this attribute clearly distinguishes compact chernozems from the other subgroups of the chernozem group.

The values for field moisture capacity in Table 4 were obtained by the following method. Fallow plots of 6 m² were selected in November, 1955 on areas plowed to 22-25 cm. Initial soil moisture at this time was close to the WM. The plots were diked, and 2700 liters of water were poured on each area in the course of 2 days (i. e., approximately half the full moisture capacity at a depth of 200 cm).

Precipitation was plentiful from November 10, and 460 mm fell by March 1, 1956. The snow thawed at this time and the surface of the areas was covered with half a meter of straw to prevent surface evaporation. The weather was clear from March 12, and no rain fell until March 25-28, when samples were taken to determine (FMC).[3]

'he process of the absorption of water vapor by particles when determining MH occurs in the n in the first 12 days, and the additional absorp- in the subsequent 48 days is only 1.59%.

laximum molecular water capacity was determined a hydraulic press at a pressure of 100 kg/cm² for nin.

[3] We were unable to obtain sufficiently reliable results from repeated attempts to determine FMC by flooding areas in the spring and early autumn, since the water is absorbed fairly rapidly into the ground in the summer down to the level of the compact horizon and begins to flow out to the sides after the upper part has swollen. In the autumn, when compact chernozems are separated into large clods, water poured

Footnote 3 continued in 1st col. on next page.

Table 4

Forms of water in a compact chernozem as percentages of an absolutely dry sample

Horizon	Depth, cm	Maximum hygroscopic	Max. molecular moist. cap.	Wilting moisture	WM/MH	Field moist. cap.	Saturated moist. cap.	FMC as a % of SMC	
								In the compact	In the leached
								Chernozem[a]	
A_1	0—10	14,2	17,5	21,3	1,50	39,9	68,8	58,1	56,5
A_2	23—30	14,9	18,0	22,4	1,50	38,2	59,9	65,1	—
B_1	60—70	16,8	19,3	23,4	1,39	23.1	38,4	94,1.	67,1
B_2	120—130	15,8	18,4	22,7	1,43	31,7	34,8	91,1	62,2
BC	160—168	15,2	17,4	20,1	1,31	27,8	32,4	85,8	61,6
C_2	230—240	14,2	16,2	19,0	1,33	25,3	29,3	86,2	—

[a] Calculated from Kostylev's figures.

Note: Comma represents decimal point.

The FMC in the compact chernozems was found to be: 39.9%-38.2% in the A_1-A_2 horizon, 36.1%-31.7% in the B_1-B_2 horizon, and 27.8%-25.3% in the BC-C_2 horizon. This is 5%-7% higher than in the same horizons in the carbonate and leached chernozems of Western Ciscaucasia, owing to the finer texture and other features of compact chernozems.

The field moisture capacity, expressed as a percentage of saturated moisture capacity, is a high value in compact chernozems, especially in the central and lower parts of the profile, where it attains 85%-94%. In leached chernozems this index does not exceed 67.1%. This difference is an indication of the very unsatisfactory air capacity of the B horizon in compact chernozems.

The values for saturated moisture capacity (SMC) in compact chernozems given in Table 4 were obtained by calculation (13), since attempts to determine it by the usual method did not give satisfactory results. The SMC for the B and C horizons of the leached chernozems was arrived at by the same method. The values were 54.1% in the first case, and 51.3% in the second.

On comparison of the indices for saturation moisture capacity in compact and leached chernozems, it becomes apparent that they differ fundamentally in this attribute as well as in other water-physical properties.

Values for the total amounts of water in mm/ha are given in Table 5. These values show that the total amount of water calculated from FMC in compact chernozems is 873 mm per hectare in a 2 m layer, that the quantity of water that corresponds to the WM is 589 mm, and the readily available moisture (RAM)[4] is 284 mm per hectare.

In the leached chernozems of the Kuban the total amounts of the same forms of water are 694, 435, and 259 mm, respectively (12).

Thus, compact chernozems are able to accumulate considerably larger amounts of moisture than are leached chernozems. On the other hand, since their WM is considerably higher, their readily available moisture is only slightly greater. The ratio of the readily available moisture to total moisture is 32% in compact and 37% in leached chernozems.

Values for porosity between aggregates and other types of porosity (Table 6) determined by Kachinskiy's method reveal the relationship between the categories of water that differ in their availability to plants, the degree of aeration, and other genetic and productive features of compact chernozems. It is found that a considerable volume of the pores (9%-10% in the A_1 horizon and approximately 15% in the lower-lying horizons) is occupied by maximum hygroscopic (inactive) water (P_{MH}). The total quantity of pores occupied by maximum hygroscopic and loosely bound (P_{S-I}) water (P_{LBW}) is 14.2% in the A_1 horizon and approximately 24 25% in the B horizon (compact). This shows that the incidence of inactive pores in compact chernozems is high. If one bears in mind that the water which they contain is not utilized by plants and that it almost completely fills all the spaces within the aggregates, it becomes evident that inactive pores are also a basic feature of aggregate porosity. There is little available water to plants in the aggregates. Thi is a typical feature of structureless fine-textured soils.

The quantity of pores occupied by capillary water (P_{CAP}) is slight: 17.5% in the A_1 horizo

---

onto the flooded area runs away down the cracks and there are great variations in soil moisture determined at definite intervals, since wetting within the clods is considerably less than on their surfaces. Suitable conditions for continuous, thorough and prolonged wetting only exist in the late autumn and winter.

[4] The RAM was determined from the difference between FMC and WM.

Table 5

Total amounts of water in a compact chernozem, mm/ha

Horizon	Depth, cm	MH	WM	FMC	Readily available moisture	RAM as a % of FMC
A_1	0—23	31,5	47,2	88,1	40,9	46,4
A_2	23—51	52,5	75,3	122,9	47,6	38,7
B_1	51—94	99,5	138,4	210,0	71,6	34,1
B_2	94—153	132,5	190,2	265,5	75,3	28,3
BC	153—168	33,6	44,1	61,3	17,2	28,0
C_1	168—200	71,8	94,1	125,4	31,3	25,0
Total	—	301,8	589,3	873,2	283,9	32,5

Note: Comma represents decimal point.

Table 6

Differential porosity of compact chernozem in percentages by volume

orizon	Depth, cm	$P_{M\text{-}AGG}$	P_{MH}	P_{LBW}	P_{CAP}	P^a_W	P_{AER}
A_1	0—10	40,3	8,9	5,3	17,5	31,7	32,9
A_2	23—30	36,3	10,7	6,9	17,1	34,8	25,9
B_1	60—70	27,4	15,5	9,3	17,2	41,9	9,8
B_2	120—130	23,8	15,0	9,0	12,8	36,7	12,7
BC	160—168	22,2	14,9	8,9	11,3	35,2	12,5
C_2	230—240	19,1	14,6	9,7	9,7	33,1	12,1

---

[a] $P_W = P_{MH} + P_{LBW} + P_{CAP}$.

Note: Comma represents decimal point.

% in the B_1 horizon and 12.8% in the B_2 zon. Kachinskiy found that active pores pied by capillary water in the correspond- orizons of a leached chernozem in the k Oblast' accounted for 37.68%, 22.18% and 5%, respectively.

eration porosity P_{AER} is represented sole- the spaces between aggregates. Aeration s are absent within the aggregates, where- other chernozems they occur both between vithin the aggregates. At and below the B_1 zon aeration porosity is not satisfactory griculture, since it is less than 20% of the pore space (10).

here is considerable porosity between the egates: 40% in the A_1 horizon, 27% in the orizon and a reduction to 19% in the C_2 zon. When compact chernozems are wetted st up to FMC, the porosity between aggre- s in the compact horizon is made up ex- vely of capillary spaces, but large cracks descend vertically for 180-200 cm develop the soil dries out.

Received March 3, 1960

BIBLIOGRAPHY

VDEYEVA, A. V. 1930. Soils of the foothill regions of the Kuban district. Tr. Gos. in-ta tabakoved., No. 75.

2. BLAZHNIY, YE. S. 1930. Plain soils of the Abinsk and Seversk regions of the Kuban. Tr. Gos. in-ta tabakoved., No. 75.

3. BLAZHNIY, YE. S. 1932. Soils of the Adigei Autonomous Oblast'. Tr. Adygeyskogo n.-i. in-ta.

4. BLAZHNIY, YE. S. 1933. Soils of the Laba-Belaya watershed. Sb. materialov pochvenno-agronomich. obsled. b. Maykopskogo okruga Severo-Kavkazsk. kraya.

5. VADYUNINA, A. F. 1950. The water regime of certain soils in the Central Urals. In the book: An attempt to make an agrophysical classification of soils, based on the Central Urals. Izd. Akad. Nauk SSSR.

6. VITYN', YA. YA. 1914. Soils of the tobacco plantation district in the Kuban Oblast' and on the Caucasian Black Sea coast. StPb.

7. VOLOBUYEV, V. R. 1948. Compact chernozems. Pochvovedeniye, No. 11.

8. ZONN, S. V. 1950. Mountain-forest soils of the North-western Caucasus. Izd. Akad. Nauk SSSR, Moscow-Leningrad.

9. KACHINSKIY, N. A. 1943. Methods for particle-size and microaggregate analysis of soil. Izd. Akad. Nauk SSSR, Moscow-Leningrad.

10. KACHINSKIY, N. A., A. F. VADYUNINA, and Z. A. KORCHAGINA. 1950. An attempt to make an agricultural physical classification of soils, based on the Central Urals. Izd. Akad. Nauk SSSR, Moscow-Leningrad.

11. KOCHERINA, YE. I. 1952. Physical properties of soils of the Kutuluk River terraces in the Kuybyshev Oblast'. Tr. Pochv. in-ta im. V. V. Dokuchayeva Akad. Nauk SSSR, Vol. 37.

12. KUZNETSOV, I. A. Water-physical properties of western Ciscaucasian leached chernozems and their improvement. Thesis. Krasnodar archives of the Food Industry Institute.

13. RODE, A. A. 1952. Soil moisture. Izd. AN SSSR.

14. TYUREMNOV, S. I. 1930. Description of the soils of the Goryache-Klyuchevskiy district. Tr. Gos. in-ta tabakoved., No. 75.

15. TYUREMNOV, S. I. 1929. Annual variation in moisture and the factors that affect it in a western Ciscaucasian leached chernozem. Tr. Kub. S.-kh. in-ta, Vol. 1, No. 2, Krasnodar.

16. YAKOVLEV, S. A. 1914. Soils along the Armavir-Tuapse railroad. Soobshch. 16, StPb.

LCULATION OF THE MIGRATION OF CERTAIN COMPOUNDS SOIL BY USING CHROMATOGRAPHIC COLUMNS LYSIMETERS

KAURICHEV and YE. M. NOZDRUNOVA, Timiryazev Agricultural Academy

Study of contemporary soil-formation proc-
es is of great importance to an understand-
of soil genesis and to develop the most ef-
tive measures for regulating these processes
rder to increase soil fertility. The study of
solutions plays an important part in this
blem, since they are the most dynamic part
he soil and a distinctive indicator of the
ection and intensity of the processes taking
ce within it.

The study of soil solutions has its own ex-
sive history. The literature of the subject
sents an interesting paper by Skrynnikova (5).

A knowledge of the composition of soil solu-
s becomes of particular importance when
is studying the migration of various com-
nds in the soil. Several investigators have
gested methods for the study of natural soil
itions. Extraction of soil solutions under
ssure (4) has been extensively used. When
g this method to study migration, one has
ake repeated samples of soil, which is
rious and makes it difficult to make simul-
eous studies at several points. The method
s not provide a direct answer to the question
he magnitude of the migration of the various
pounds.

We have attempted to develop a method in-
ving the chromatographic columns of
meters to study the migration of iron com-
nds in various soils.

The chromatographic method is, of course,
ed on ionic and molecular absorption. We
blished, by the use of various methods (in-
ling the chromatographic method), that
er-soluble iron compounds formed by the
on of the decomposition products of plant
dues (litter fall from trees, grass residues)
gleyed soil, are of various forms and in-
e organo-mineral compounds of iron of a
complex nature (1). Similar compounds
been found also to be present in the com-
tion of the soil solutions of sod-podzolic
s (2). These compounds pass through both
on- and anion-exchange resins. It has been
wn by laboratory tests that organo-mineral
pounds of iron of this complex nature are
adsorbed by aluminum oxide, which is one
he most widely employed adsorbents in
matography, especially for some types of
nic compound (alcohols, phenols, carboxylic
acids, esters, amino acids, carbohydrates, natural pigments, etc.) (6). This adsorbent has a high adsorption capacity and with suitable treatment can be prepared as an ion-exchange adsorbent (cationite or anionite). Aluminate aluminum oxide is prepared by treatment with alkali and emerges as a cationite in the sodium form.

When aluminum oxide is treated with nitric acid it emerges as an anionite in the nitrate form. Whereas neutral aluminum oxide is only capable of molecular adsorption, it also adsorbs ions, without any loss of its molecular adsorptive capacity, when it is prepared as an anionite or cationite. Therefore, if one packs a column with successive layers of anionite, cationite, and aluminum oxide, one should obtain maximum adsorption of iron compounds from a solution filtered through it.

We verified this assumption in an extensive series of laboratory tests. We used glass tubes (8 cm in diameter) with a funnel-shaped contraction at the base, to which we fastened a rubber tube with a pinchcock. The lower part of the tube was filled with glass wool for drainage. The tubes were then filled with pure quartz sand separating layers of various adsorbents. The sample of soil material—clay loam from a depth of 80-100 cm passed through a 3 mm mesh sieve—was sprinkled on top of the sand. The surface of the soil material was covered with various types of litter. Sufficient distilled water was then added to the tube for the plant residues to be excessively moist during decomposition. The experiment was maintained in this condition for 1 month at a temperature of 18^0-22^0C.

During this time reduction processes that occurred in the soil material as a result of the water-soluble organic matter in the litter led to the formation of various forms of water-soluble iron. At the end of the experiment the water was drained off from the bottom of the tube, in the course of which it passed through the layers of different adsorbents. The results of one experiment of this type are given in Table 1.

It is evident from Table 1 that the bulk of the iron is retained on the aluminum oxide. Of 125 mg of total iron in the solution, the aluminum oxide retained 110 mg or 88%.

Thus, if a chromatographic column is prepared

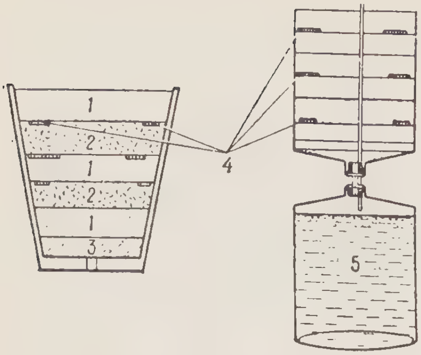


Fig. 1. - Chromatographic columns for extraction of soil solutions.

1 - sand, 2 - adsorbent, 3 - glass (for drainage), 4 - tubes containing silica impregnated with α-α'dipyridyl, 5 - soil solution after passage through soil and adsorbents.

in the normal manner and inserted under natural conditions in the soil profile at the required depth, the adsorbent will adsorb the various substances contained in solution, including iron compounds, when descending currents of water are filtered through the column.

When studying the dynamics of oxidation-reduction processes we used various adsorbents for quantitative calculation of the migration of iron compounds and organic matter. The technique which we employed with the chromatographic lysimeter columns was as follows.

In preparing the columns we used wooden boxes, the insides were coated with Mendeleyev's compound, with apertures in the base, 3-5 liter glass bottles and flower pots. The latter are very useful when one is setting up a large number of columns. Lysimetric columns of this type are shown in Figure 1. They can be prepared so that the solution is collected in a container (B) after filtration through the column, or without a container (A). In qualitative analysis of the iron compounds filtered through the column, we usually inserted glass tubes filled with amorphous silica impregnated with an 0.5% solution of α-α dipyridyl in the column above the layers of adsorbents. The presence of ferrous oxide in the solution was shown when the silica in the tubes turned red. The sand with which the columns were packed was prepared as for a pot experiment.

Aluminum oxide was used extensively for the adsorbents in the columns, but KU-2 and KB-4 cation-exchange resins in the H^+form were used in some cases. The aluminum oxide was thoroughly mixed with washed quartz sand (1:1 o 1.5:1) to improve filtration. The thickness of the adsorbent layer depends on its adsorption capaci and the quantity of migrating substances thought be involved, as well as on the time for which the columns will remain in the soil.

When using aluminum oxide as the adsorbent in columns which will be used for a whole year to estimate the migration of iron and organic matter, it is desirable that there should be at least two layers of adsorbent no less than 2.5 cm thick in the column.

The columns are inserted in the soil profile i the following manner. The soil profile is excavated at a suitable site. As the hole is dug the soil is carefully put aside layer by layer. A groove is then cut in the front or side face of the profile away from the earth set aside when the hole was dug. The column is inserted into the groove to a depth of 5-10 cm and the free space in front and to the sides is carefully packed with soil from the correct genetic horizon. The colu must be so placed in the groove that its surface in intimate contact with the upper part of the groove, i.e., directly in contact with the soil layer above the column. The columns are inserted at depths governed by the purpose of the research, and it is desirable that at least two should be inserted at each depth. The columns are left in the ground for as long (season, vegeta tion period, year, etc.) as is required by the investigation. We have made extensive use of these columns when studying the migration of ir in the soils of the forest-meadow zone.[1]

---

[1] I. V. Zaboyeva, A. N. Tsypanova, and L. N. Frolova of the Soil Department of the Komi Filial, USSR Academy of Sciences collaborated with us in establishing columns in the soils of the Komi ASSR.

Table 1

Adsorption of iron by different absorbents

Treatments	FeO content of drainage waters, mg/1			
	ionic		Total iron (after oxidation of organic matter in solution)	Taken up by adsorbents
	FeO	Fe_2O_3		
I Control—pine needles, soil material	90,0	None	125,0	—
II Pine needles, soil material, KU-2 cationite in the H form	0,6	"	70,0	55,0
III Pine needles, soil material, EDE-10 anionite in the OH form	7,0	"	84,0	41,0
IV Pine Needles, soil material, Al_2O_3	0,7	"	15,0	110,0

Note: Comma represents decimal point.

Table 2

Removal of iron per m² of area

Soil	Horizon	Depth, cm	Fe retained by adsorbent, mg/m²			
			0,1 n H_2SO_4		10%HCl	
			Total	Combined with organic matter	Total	Combined with organic matter
Timiryazev Academy's forest plantation (3-year period)						
Sod-medium podzolic a) grass	A_1	0—22	Not det'd.		284	Not det'd.
	A_2	22—33	"		415	"
b) larch plantation	A_1	0—19	"		164	"
	A_2	19—34	"		356	"
Belyy Rast, Moscow oblast' (2-year period)						
Profile 1. Strongly podzolic, dense fir forest	A_0	0—4	296	52	1126	386
	A_2	4—25	246	52	1065	585
	A_2/B_1	25—60	300	54	874	287
	B_1	60—80	289	147	867	296
Profile 1. Gleyish podzol, moss, mixed forest	A_0	0—4	255	34	773	287
	A_1/A_2	4—9	297	61	636	262
	A_2	9—35	295	83	921	504
	A_2/Bg	35—80	347	121	2243	1662
Komi ASSR (1-year period)						
Profile 2. Strong podzolic	A_0	0—7	359	274	1157	747
	A_2	7—16	345	241	1308	735
	A_2/B_1	16—38	330	235	1337	659
	B_1	38—60	531	351	1538	793
Profile 3. Peaty-podzolic-gleyed	A_0	0—10	400	301	1166	587
	A_2	10—22	566	334	2467	887
	A_2/Bg	22—54	264	191	1056	217
	B_{1g}	54—75	400	332	1246	369

Note: Comma represents decimal point.

t the end of the period the profile is ex-
ted and the columns are removed for subse-
t analysis of the adsorbent. Care must be
n, when removing the adsorbent from the
mn, that no soil particles from the surface
e column fall onto the adsorbent. An
age sample is carefully prepared for
ysis. The calculation is made for the whole
r of the adsorbent. When there are several
rs in the column, each layer is analyzed
rately and the calculation for the total
unt of adsorbed matter in the column is sub-
ently converted to a unit of area. Values
he adsorption of iron in columns set up at
ous points are shown in Table 2.[2] The iron
extracted by successive treatment of the adsorbents with 0.1 N H_2SO_4 and 10% HCl and determined titanometrically in the extract before and after destruction of the organic matter.

The figures in Table 2 show that there is variation in the scale of migration of iron compounds in the soils of the test plots. They reveal clearly the specific nature of soil processes in forests of different types in relation to climatic and hydrological conditions and the nature of the vegetation. If the figures from all points are converted to an annual basis, the amount of iron adsorbed by the lysimeters in the soils of the Timiryazev Academy's forest plantation, in the damp mossy soils of the Moscow Oblast', and in the soils of the mid-taiga forests of the Komi ASSR, stand in the relative relationship of 1-7-20.

Lysimeter data give a clear picture of the nature of contemporary processes in the migration of substances and, in particular, enable one to assess the development of the podzolization

---

. L. Shishov and Li-Chan wey collaborated in the
work, and M. N. Rytikova in analysis of the ma-
ls.

Table 3

Adsorbents for use in the preparation of lysimeter chromatographic columns

Adsorbs	Adsorbent	Form
Phosphate ions	EDE-10 Al_2O_3	OH NO_3
SiO_2	EDE-10-π	OH
SO_4	Al_2O_3	NO_3
Cl	MG-1 MMG-1	OH
Ca Mg	KU-2	H
Al	KU-2	H

process. In the grass-forests of the southern taiga, which have well-drained soils, the biological accumulation of iron compounds exceeds their removal.

Even now podzolization occurs only in the southern taiga in the humid forests, where there is some seasonal water-logging of the soils. In this respect, the values we obtained with lysimeter columns agree well with the conclusions arrived at by Skrynnikova (5) from a study of the composition of soil solutions obtained by Kryukov's method. The lysimeter values show that the migration of iron can be seen most clearly in the central taiga. It may be thought that present day conditions in this subzone are favorable to the widespread development of podzolization.

The results obtained show that the method of lysimeter chromatographic columns enables one to assess the rate as well as the direction of the process, and this is both interesting and important. It can be seen from Table 2 that a considerable quantity of the iron migrates as stable organo-mineral compounds.

Our studies show that a large part is played in the processes of iron migration in soils by compounds of a nonspecific nature such as tannin and its derivatives and low molecular carboxylic acids (3).

The method can also be used to study the migration of many other compounds and elements in addition to iron and organic matter. The existing adsorbents can be used extensively to estimate the migration of substances in a molecular-soluble form or as ions. It is certainly of interest to study the migration of Al, Ca, Mg, phosphoric acid, and silica. In saline soils it is of great importance to estimate the migration of the cations and anions of water-soluble salts.

We have not made any special study of the use of different adsorbents. A list of adsorbents (compiled from the literature) for use in adsorbing different substances from soil waters is given in Table 3. The preparation of these adsorbents is described in chromatography manual

In studying migration processes it is of importance to estimate the reverse processes, i.e., the migration of compounds when ascending currents develop, as well as migration with the downward current. This aspect is of particular interest when studying the process by which soils become saline, and also in relation to specific features in the genesis of certain soils (soils wit iron accumulation at the surface, yellow-podzoli lateritic, etc.). There is no objection in principle to the use of chromatographic column meth in this case.

Conclusions

1. It is suggested that lysimeter chromatographic columns should be used to estimate the migration of various compounds in soils.

2. Use of this method when studying the migr tion of iron compounds in virgin podzolized and sod-podzolic soils of the forest-meadow zone shows that the removal of iron is widespread in the central taiga subzone. In the southern taiga subzone loss of iron occurs only in present day conditions in the humid mossy forests in which seasonal excess moisture develops from time to time.

Received May 9, 1960

BIBLIOGRAPHY

1. KAURICHEV, I. S., YE. V. KULAKOV and YE. M. NOZDRUNOVA. 1958. The formation and migration of organo-mineral iron compounds in soils. Pochvovedeniye, No. 12.

2. KAURICHEV, I. S., YE. M. NOZDRUNOVA, and M. N. RYTIKOVA. 1959. The formation of organo-mineral compounds by the action of water extracts of plant residues on gleyed soil. Izv. TSKhA, No. 3.

3. KAURICHEV, I. S. and YE. M. NOZDRUNOV 1960. The role of the components of water soluble organic matter in the formation of groups of organo-mineral iron compounds. Dokl. TSKhA, No. 52.

4. KRYUKOV, P. A. 1947. Soil solution extraction methods. A guide to field and laboratory methods of studying soils. In: Up-to-date methods of studying the physical and chemical properties of soils, (4)2.

5. SKRYNNIKOVA, I. N. 1959. Soil solutions o the southern part of the forest zone and their role in soil-forming processes. Tr. Pochv. in-ta im. V. V. Dokuchayeva Akad. Nauk SSSR.

6. SHEMYAKIN, F. M., E. S. MITSELOVSKIY, and D. V. ROMANOV. 1955. Chromatographic analysis. Goskhimizdat.

JMUS DISTRIBUTION IN THE TUNDRA SOILS F NORTHERN YAKUTIA

A. KARAVAYEVA and V. O. TARGUL'YAN, V. V. Dokuchayev Soil Institute, Academy of
ences, USSR

Tundra soils are among the least studied of
soils. Only a very small area of the circum-
ar tundra zone, including the East European
tinental tundras, part of the West Siberian
dras (5, 6, 7, 8, 10, 11), the tundras of the
thern coast of Alaska (16, 17), and some of
islands in the Polar basin, has been
cribed from the point of view of soil. The
dra soils of the highly continental regions of
a and the Canadian North, which make up the greater part of the tundra zone, have been studied very little.

Our work concerns the tundras of Yakutiya in the lower reaches of the Lena and Indigirka Rivers.[1]

Table 1

Climatic data for the tundra zone

Regions of tundra zones	Latitude	Mean annual air temperature	Mean temperature		Total of temperature readings			Mean annual temperature of soil parent materials	Precipitation in warm period	Annual precipitation
			Jan.	July-Aug.	>0°	>5°	<0°		in mm	
Arctic subzone										
Eastern Europe	69°43′—70°24′	— 7,4	—19,7	5,8	460	39	2500	— 4,0	182	304
West Siberian	71°30′—73°20′	—10,4	—23,4	5,7	387	27	—	— 8,0	149	228
Lower Lena	71°35′—72°52′	—13,7	—33,7	8,5	625	186	5500	—11,0	171	221
Indigirka	71°00′	—15,2	—36,0	8,7	628	159	5500	—11,0	85	128
Moss-lichen subzone										
East European	69°09′—69°00′	— 5,8	—16,4	6,9	589	99	—	— 2,0	200	300
West Siberian	70°09′—71°02′	—10,5	—23,2	8,2	589	168	—	— 6,0	128	284
Shrub subzone										
East European	68°14′	— 4,8	—16,9	10,3	900	312	—	— 1,0	170	344
West Siberian	67°42′	— 9,1	—26,0	10,2	804	320	—	— 4,0	247	343
Indigirka	70°37′	—14,2	—36,2	10,2	760	254	—	— 10	85	128

Note: Comma represents decimal point.

---

[1] Professor Ivanova directed field work in these districts in 1956-1957.

Table 2

Particle-size analysis of tundra gley soils. Content of fractions as percentages (analyst S. K. Antropova)

Profile Number	Horizon	Depth, cm	Losses from treatment with HCl	Diameter of particles, mm						<0.001 mm diameter part. after treatment with H_2O_2	% of physical clay
				1,0—0,25	0,25—0,05	0,05—0,01	0,01—0,005	0,005—0,001	<0,001		
76	A_0	6—10	3,92	22,30	12,92	31,96	3,91	11,48	13,51	2,33	28,90
	C	10—15	1,48	9,78	17,59	22,97	8,77	23,26	16,15	13,50	48,18
	C	20—25	1,34	9,38	17,80	23,34	8,53	23,05	16,56	12,72	48,14
	C	35—40	2,11	7,62	15,16	23,01	10,20	25,79	16,11	13,26	52,10

Table 3

Total chemical composition of tundra gley soils (analyst K. Ya. Dorokhova)

Profile Number	Horizon	Depth, cm	Ignition losses, %	As a % of the ignited sample								Total
				SiO_2	R_2O_3	Fe_2O_3	Al_2O_3	CaO	MgO	K_2O	Na_2O	
120	A_0	7—13	34,26	67,74	23,75	5,13	18,60	5,95	2,52	0,49	0,47	100,92
	G	15—25	4,68	73,80	19,72	8,65	11,19	2,97	0,85	1,90	2,30	101,54
	G	30—40	3,87	73,50	20,02	3,38	16,81	3,42	0,61	1,40	2,56	101,51
	G	50—55	6,07	73,49	19,85	3,06	16,04	3,11	0,55	1,82	2,20	100,02
76	A_0	6—10	29,44	68,00	23,19	7,51	15,68	1,49	2,28	2,19	2,39	99,54
	G	10—15	7,53	70,16	23,30	5,71	17,59	0,76	1,80	1,17	2,05	99,24
	G	20—25	7,46	70,50	23,22	5,10	18,12	0,76	2,09	1,33	2,28	100,18
	G	35—40	10,80	69,16	24,77	6,57	18,20	1,10	2,01	0,98	1,64	99,66

Note: Comma represents decimal point.

Climatic conditions make the Yakutian tundras the most continental of the Eurasian tundras of the USSR (Table 1). They have high summer and relatively low winter air temperatures and the lowest mean annual air temperatures. Annual precipitation is lower. The high totals for negative temperatures (of the order of 5000°-5500°C) help to accumulate considerable amounts of cold in the soil. The relatively greater intensity of biological processes in the Yakutian tundras during the summer is due to the higher totals of positive temperatures and temperatures above 5°C. Nevertheless, the large amounts of cold in the soils ensure that they only thaw to a slight depth, and this has its effect on soil formation in these districts.

Tundra gleyed soils on clay loams (eluvial-deluvial Cretaceous sandstones and shales) in the undulating plain tundra of the lower reaches of the Lena River have certain unusual morphological and chemical features.

Morphological features that distinguish tundra gley soils from the soils of the East European typical tundra include: 1) the permafrost horizon lies high in the profile (within 40-50 cm of the top surface in clay loams); 2) the mineral gleyed part of the profile has an unusual structure, in which the upper horizon is greatly oxidized, owing to excellent aeration in the overlying organogenic horizon. The lower horizons in the profile, above the impervious permafrost layer are saturated and inaccessible to air and are the most highly gleyed horizons in the profile; 3) there is a distinct organogenic (humus) horizon in the upper part of the profile, beneath the litter, which is not normally gleyed. The average thickness of this horizon is 5-15 cm. The development of a horizon of this type is connected with the high temperatures and temperature totals of the warm period, which cause a great increase in plant mass and provide conditions favorable to its decomposition (1); and 4) thixotropic features are rare or totally absent in the soils. We failed to find any such signs in the tundras of the lower reaches of the Lena and Indigirka Rivers or in the Aleksandrovaya tundra on the Popigay (2), although they are widespread in the Far North of Europe and Western Siberia.

We shall give a morphological description of two soil profiles from the Lower Lena tundras on coarse and fine clay loam:

Profile 120. Flat summit of a ridge in the northern foothills of the Chekanovskiy range, dipping slightly to the southeast. Surface slightly tummocked and lumpy. Dryad-cotton grass plant association. Two shrub species of willow, Polar willow, sedge, wood-betony. Mosses - Helacomium, Ptilidium and Campotecium.

A_0' 0-7 cm. Live carpet of moss.

A_0'' 7-13 cm. Dark cinnamon-brown, humified, damp. Many roots. Abrupt transition.

G' 13-27 cm. Unevenly colored, rusty-rown and dark blue patches on a brown ground. oarse clay loam. Moist. Many roots. Clear ansition.

G'' 27-41 cm. Mottled, rust and dark blue tches, coarse clay loam. Moist. Few roots. brupt transition.

G''' 41-55 cm. Dark blue coarse clay am. Frozen. No roots.

Profile 76. Slope from Mt. Lyel'kina to the a at Tiksi, facing 2°-3° to the East. Surface ightly irregular. Cotton grass-sedge-moss getation. Shrub willow on high ground. Wood tony, groundsel. Mosses - *Aulacomnium*, *elacomium* and *Dicranum*.

A_0' 0-6 cm. Live carpet of moss.

A_0'' 6-10 cm. Humified grey-brown with nnamon-brown tinge. Damp. Many roots. lear transition.

G' 10-15 cm. Dark to light blue clay loam ith pale yellow patches. Moist. Many roots. lear transition.

G'' 15-30 cm. Dark blue clay loam with ownish tinge. Frozen. Few roots. Clear ansition.

G''' 30-40 cm. Same as previous horizon, it with more ice.

The texture of these soils is quite uniform 'able 2). We did not notice any signs of clay igration either in analytical or in micromor-ological study of microsections of the soils. e total chemical composition was quite uni-rm in the different genetic horizons, but there as a tendency for all the iron to accumulate in e upper part of the profile (Table 3). These ils have an acid reaction—pH 4-5, and the un-turation reaches considerable levels (approx. %, Table 4).

We have deliberately given a very brief scription of the properties of the tundra gley ils of the Yakutian tundras, since we shall blish all the material at our disposal concern-g these soils in a separate paper. The object this paper is to deal specifically with one of e basic features of these soils—the processes which organic matter is accumulated and stributed in them.

In the profile of these soils clear morphologi-l coloration by humus is only noticeable in the per organogenic horizon. The very lowest rizon of the profile is sometimes slightly rkened. Nevertheless, analysis shows that e soils are humified to a considerable extent roughout the whole depth to which they thaw. umus distribution is fairly even throughout the il layer and there is slight accumulation in the west horizons (the frozen horizon and the one mediately above it)(Table 4).

The humus profiles of Yakutian tundra gley ils are shown in Figure 1 with similar pro-es for East European and West Siberian tun-as. All the soils shown in the Figure 1 were veloped under zonal conditions on clay loam soil-forming parent materials. Those horizons that are evidently morphologically humus horizons are indicated by heavy vertical shading, while the colorless humus that impregnates the mineral layer is indicated by light oblique shading. Diagrams 6-8, with humus distribution in the soils of the Lower Lena tundras, show that the profiles of these soils are impregnated with colorless humus (1.5%-3%) to a considerable depth. This impregnation is often accompanied by increased humus content in the lower horizon of the profile, immediately above the permafrost, as is shown on the diagrams by the quite distinct lower peak. This accumulation of humus above the permafrost sometimes may be quite considerable (approx. 8%).

Note that the humus profiles of most soils in the East European tundras are quite different—they have a thin upper horizon of accumulated peaty organic material, the quantity of which decreases rapidly with increase in depth until its content is negligible at less than 1%.[2]

In the East European tundras one only finds indications that the soil layer is impregnated with humus in the northern subzone, in soils in which the permafrost lies fairly close to the surface (less than 1m) (6, 11). The same phenomenon is apparently encountered to some extent also in the northern subzone of the West Siberian tundra (Diagram 5, Gorodkov, 1932).

The high relative content of humic acids is a distinctive feature of the qualitative composition of the humus of the gley soils of the Yakutian tundras. Unlike other soils, the lower horizons are found to contain approximately the same quantity of humic acids as the upper horizons. It is evident that the structure of the humic acids in these soils is simplified and therefore they are able to pass into solution and migrate from the area in which they were formed (the upper horizons) to the lower horizons, where they accumulate. The values in Table 5 show that the fulvic acids in these soils are also fairly mobile. Approximately 40% of the total amount of organic matter passes into the extract when these soils are directly treated with 0.1 N NaOH. The fractions connected with Ca are very small or entirely absent. Apparently, the great many substances extracted by benzene-alcohol contain a high percentage of the components that are difficult to decompose in certain types of plant residues (sedges and cotton grass). The humic acid fractions predominate in the group composition of the humus (C of the humic acids : C of the fulvic acids ~1). The soils of the Yakutian tundras differ in this respect from those of the East European shrub tundras, in which the fulvic acids predominate greatly in the composition of the humus (13).

Thus the processes of humus formation in the lower Lena amount to the accumulation of a large quantity of fairly mobile humic matter in the upper horizons of the soils. Note that filtration of

---

[2] Figure 1 shows typical humus profiles for the soils of the East European tundras: 1 - profile 40, B.N. Gorodkov, 1932; 2 - profile 109, Yu.A. Liverovskiy, 1934; 3 - profile 2, N.A. Kreyda, 1958; 4 - profile 1-P, O.A. Polyntseva, 1952.

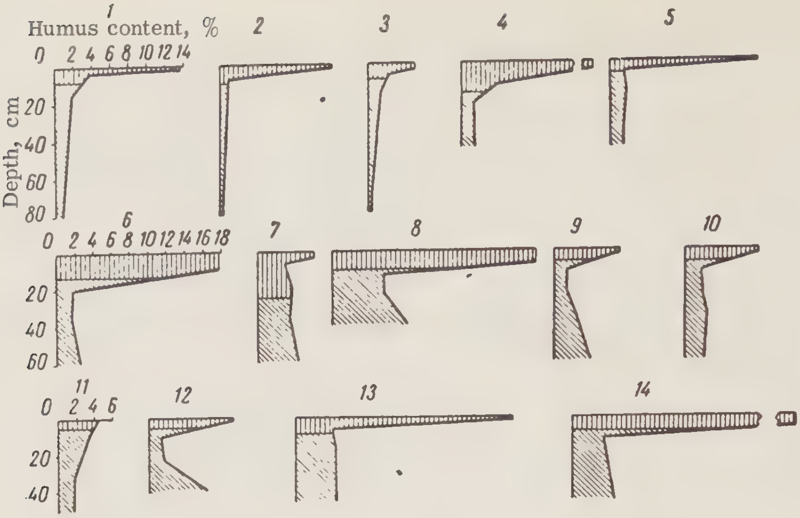


Fig. 1. - Humus profiles of the soils of various regions in the tundra and taiga zones.

East European tundra soils: 1 - medium podzolized, surface gleyed clay loam, shrub tundra subzone; 2 - gley soil with distinct gley horizon, clay loam, typical tundra subzone; 3 - surface gleyed clay loam, typical tundra subzone; 4 - surface gleyed clay loam, typical tundra subzone. West Siberian tundra gley soils: 5 - loam, typical tundra subzone. Lower Lena tundra gley soils: 6 - coarse clay loam, profile 120; 7 - coarse clay loam, profile 101; 8 - fine clay loam, profile 76. Indigirka tundra gley soils: 9 - clay loam; 10 - coarse clay loam. High Arctic tundra soils of the island of Bol'shoy Lyakhovskiy: 11 - non-gleyed clay loam of polygonal tundra; 12 - gleyed clay loam of mottled tundra. Frozen taiga soils of the northern sparse forests in the lower reaches of the Lena River: 13 - gleyed fine clay loam; 14 - slightly gleyed clay loam.

moisture in the thawed layer of tundra gley soils is made difficult by their comparatively low permeability to water. It can be assumed that the intensive transfer of dissolved humic matter from the upper to the lower horizons is effected in two ways in these soils: 1) during the thaw, when the filtering capacity of the soil layer is considerably enhanced (15). A similar effect also can be observed in the soils of the East European tundras, but conditions on the lower Lena are more favorable to the development of downward flow during the thaw, owing to the absence of thixotropic features; and 2) by frozen migrations of solutions to the cold front (the upper boundary of the permafrost layer). These migrations are of downwards direction in the summer and apparently involve the whole soil stratum owing to the slight thickness of the active layer. In the east European tundras summer frozen migrations of solutions probably will be considerably modified and reduced in intensity (10, 11), owing to the greater depth of the permafrost (~1 m in clay loams).

It follows from what has been said that conditions are more favorable to downward flow of soil solutions (and humic matter) in the tundra soils of the lower Lena than in those of the East European tundras. At a depth of 40-50 cm these quite intensive downward flows are halted by the impervious frozen horizon. Lateral intra-soil flow is difficult in tundra soils owing to the low permeability of the gleyed horizons. The humic matter in the downward flow is therefore distributed in the restricted range of the thin soil profile, which it completely permeates. The content of humic matter immediately above the permafrost horizon is normally increased by mechanical retention over the frozen obstacle to the flow of water and to attraction to the cold front of the permafrost. Humic matter that penetrates into the soil profile accumulates in it gradually, since further decomposition is extremely slow in view of the low temperatures and anaerobic conditions.

This clarifies the great and diverse role of near-surface permafrost in the distribution and accumulation of humic matter in these soils. We have applied the term frozen humus-retention (from Latin word "retineo"—to hold up) to the complex of features associated with the distribution and accumulation of humus in these soils, and consider that all these features are connected with near-surface permafrost. In our opinion the frozen humus-retention involves three types of feature: 1) Intensive frozen migration of mobile humic matter down into the soil profile to the permafrost horizon (and downward flows during thawing); 2) Mechanical retention of the downward flow of humic matter over the frozen obstacle to water flow and saturation of the soil stratum with humus. The increase in the content of humic matter immediately above the frozen

Table 4

Chemical analyses of tundra gley soils (analyst V. F. Mochalova)

Profile Number	Horizon	Depth, cm	Hygroscopic moisture, %	pH		Humus, % (Tyurin's method)	Nitrogen, %	Hydrolytic acidity, meq	Exchangeable acidity (Sokolov's method)		Adsorbed cations				Unsaturation, %	Tamm's extract, mg 100 g of soil		
				water	salt				Al^{+++}	H^+	Ca^{++}	Mg^{++}	H^+	Total		F_2O_3	Al_2O_3	SiO_2
120	A_0'	7—13	5,12	—	4,8	17,02	—	5,66	—	—	43,01	3,79	—	—	—	680	—	—
	G′	15—25	1,51	—	4,2	1,72	—	4,01	—	—	8,60	0,70	—	—	—	920	—	—
	G″	30—40	1,66	—	4,9	1,60	—	4,74	—	—	6,54	1,30	—	—	—	1005	—	—
	G‴	50—55	2,37	—	4,0	2,39	—	2,75	—	—	8,14	2,87	—	—	—	795	—	—
76	A_0'	6—10	5,92	4,45	3,33	20,93	0,89	10,14	4,89	0,07	32,81	Нет	5,80	38,61	15	2210	760	410
	G′	10—15	1,61	4,51	3,55	5,45	0,17	5,20	2,44	0,02	3,69	»	4,10	7,79	52	850	620	490
	G″	20—25	1,53	4,74	3,39	5,59	0,16	4,97	2,38	0,05	3,32	0,36	3,70	7,38	50	790	600	580
	G‴	35—40	2,02	4,74	3,35	8,15	0,10	5,99	1,93	0,05	5,94	0,74	4,93	11,61	42	2430	590	360

Note: Comma represents decimal point.

Table 5

Group composition of humus of tundra gley soils as percentages of total C[a]. Profile 76 (analyst N. A. Andreyeva)

Depth	C in initial sample	C of bitumens[b]	C of decalcified	Fractions					C of residue	Total	Overall		Total N	N in residue	C : N
				Ia	I	II	III								
				Fulvic acids	humic acids + fulvic acids		humic acids	fulvic acids			humic acids	fulvic acids			
6—10	12,17	11,01	7,07	4,60	40,83	6,76	3,37	12,98	17,26	103,88	24,98	36,16	0,95	0,33	12,82
35—40	4,74	24,28	0,84	None	41,56	0,00	4,00	5,49	16,46	93,07	25,31	23,65	0,35	0,12	13,54

---

[a] Analysis by Tyurin's method as given in Arinushkina "Soil Chemical Analysis," Moscow University, 1952. The method was modified in that the humic acid fraction was not separated in the directly alkaline extract.

[b] Substances extracted by benzene-alcohol mixture.

Note: Comma represents decimal point.

horizon is a subsidiary feature; and 3) Gradual accumulation (or conservation) of the humic matter that penetrates into the soil profile, owing to the low rate of decomposition under anaerobic and low temperature conditions.

It is difficult to say which compounds of humic matter migrate in these soils. The analytical data at our disposal failed to reveal connections between the distribution of humus and any mineral components in the profile. The total chemical composition of the soils is fairly uniform; nor is there any clear correlation between humus distribution throughout the profile and the distribution of available compounds determined by Tamm's method. There must be further special study of this complicated question.

In our view there is a difference between frozen humus-retention and the humus-illuvial process as understood by Ivanova and Ponomareva (8, 9, 12, 13). Superficially the processes appear to be similar—there is a large amount of available humic matter in the soils, downward migration, and subsequent accumulation in the profile.

In our opinion, the following are the basic genetic differences: 1) The causes of downward migration in the warm period are different. In the humus-illuvial process we are concerned with downward gravitational flow of atmospheric precipitation. In the soils under consideration we are concerned mainly with frozen migrations of solutions to the adjacent cold front of the permafrost; 2) The accumulation of humic matter in humus-illuvial horizons is connected with neutralization by R_2O_3 hydrates and mutual coagulation. The B_h horizon is morphologically and chemically quite clearly delineated in the profile. In frozen humus-retention, the accumulation of humus is connected with its mechanical retention in a restricted region of the profile and subsequent conservation of the humic matter under anaerobic and low temperature conditions. This type of accumulation does not give rise to a clearly delineated illuvial horizon, and accumulation does in fact take place throughout the profile. The interactions of R_2O_3 and organic matter are clearly of secondary importance in the accumulation of humus. This is also confirmed by analysis, since no clear correlation is normally to be seen between R_2O_3 and humus distribution throughout the profile; and 3) Different and even opposing conditions are required for the fullest development of the two processes. The humus-illuvial process is typical of soils formed on coarse-textured, crushed parent materials and does not develop on fine-textured parent materials owing to the poor filtration of solutions in them (12). Frozen humus-retention, on the other hand, is most developed in fine-textured soils (4), since frozen migrations of solutions are most intensive in them, lateral intrasoil flow is at its lowest (compare profiles 120 and 76), and the permafrost layer acts as a barrier to water flow. The intensity of frozen humus-retention is also directly proportional to the amount of plant litter-fall to enter the upper organogenic horizon and to the wetness of the profile, as can be seen from diagrams 11 and 12. Diagram 11 shows a non-gleyed soil from the polygonal high Arctic tundra with very sparse vegetation and a correspondingly low annual litter-fall on the surface of the soil. Diagram 12 shows a gley soil taken from near a mottled high Arctic tundra with a quite well-developed sod.

The effect of the amount of litter-fall and moisture on the intensity of frozen humus-retention is quite apparent: the first increases the concentration of humic matter in the soil solution and the second promotes more intensive frozen migrations (4).

In soils on coarse-textured parent materials in the lower Lena tundras, humus is not found in the thawed layer of the profile, owing to the reduction of frozen migrations in coarse-textured soil materials and the high filtration capacity of the entire soil profile.

It should be noted that the concept of the humus-illuvial process was developed for the podzolized zone, although soils with acid mobile humus within the soil profile are found outside the zone. If the concept of the humus-illuvial process is widened in the course of further study, it is possible that it can incorporate frozen humus-retention.

Thus, frozen humus-retention is a specific feature of the tundra soils of the lower Lena. It is of great importance to establish how far this process holds for the frozen soils of the tundra zone as a whole and, possibly, for other zones.

We have already noted and demonstrated that frozen humus-retention is not marked in the soils of the East European tundras. In these soils there is a considerable concentration of humus in the upper humus and peat-humus horizons, the content of organic matter declines rapidly on transition to the mineral layer of the profile, and there is a subsequent gradual decrease in humus content in the lower part of the profile. Humus content does not normally exceed 1% in the lower horizons of the soils.

Soils on clay loams thaw to a depth of 1.5-2 m in the shrub tundra subzone of the East European tundras and to 0.8-1.3 m in the typical tundra subzone. Consequently the permafrost horizon is not the direct barrier to flow of the soil solutions, and its role as a lower cold front for frozen migration of the solutions is greatly reduced. The basic conditions for frozen humus-retention are absent or very poorly developed and therefore there are no traces of this process in the humus profile of these soils.

As one moves from west to east and the continentality of the climate increases, conditions evidently become more favorable to the development of frozen humus-retention. Some signs of this can already be discerned in the humus profile of soil from the Gyda tundra (Diagram 5). However, since humus was determined in this profile only to a depth of 30 cm, the traces of retention can be only tentatively identified.

This process is quite clearly defined in the tundra soils of the lower Lena and has been described in detail previously. It is equally clearly defined in the soils of the Yana-Indigirka plain (Diagrams 6-8 refer to lower Lena tundras and 9 and 10 to Indigirka tundras). The slight differences in the upper organogenic horizons are connected with the position of the profiles in

e local relief and variations in the sodding of
e soil surface. However, this does not affect
e general nature of the humus profile, in which
e soil layer is highly impregnated, and there
some accumulation of humus at depth im-
ediately above the permafrost layer.

We do not know of any values for humus con-
it in the soil profile for other regions of the
ndra zone, although there are important com-
ents on this question. Thus, at the Gorodkov
emorial Meeting in 1960, Tikhomirov noted
it there is a dark, humified horizon above the
rmafrost horizon in the soils of the Central
ymyr. In his opinion this horizon is created
the stagnation of solutions rich in humus and
sily-available mineral compounds above the
pervious permafrost horizon.

Similar comments are made in American
rk on the Alaskan tundras (16, 17). Also,
ey note the existence of a darker horizon, con-
ning more humus than the center of the pro-
e, in the lower part of tundra gley soils. This
rizon lies above a frozen soil layer, part of
ich is incorporated also. Unfortunately
ese authors do not give detailed descriptions
analytical data for the profiles. Therefore,
is difficult to make comparisons and we can-
come to any definitive conclusion on the
nesis of these horizons.

Comparison of the humus profiles of soils
om certain provinces of the tundra zone, plus
e existing morphological data, lead us to con-
ude that frozen humus-retention, saturation
the soil profile with organic matter, and its
cumulation above the permafrost, is most
arly expressed in the highly continental
gions of the Asiatic tundras. To judge by
sting information, no such features have
en detected in East European tundras.

We think that it is extremely important that
s distinctive humus distribution is not con-
ed to the tundra gley soils of the typical tundra
Northern Yakutia, but is found also in soils
the north and south of this subzone. Thus,
re are clear signs of retention (Diagrams 11
l 12) in the clay loam slightly gleyed soils of
akhovskiy Island, which we have placed in
high Arctic tundra subzone. Similar signs
found in the frozen taiga soils of the sparse
ch forests near Kyusyur in the lower reaches
he Lena River, adjacent to the tundra soils
ich we have been studying (Diagrams 13 and
.

One can assume from these data that frozen
nus-retention, which gives rise to distinctive
nus distribution in clay loams with a perma-
st layer near the surface, is typical of
ions with a cold, markedly continental
nate, and that it embraces all subzones of
tundra zone and, in all probability, the
th of the taiga zone.

In conclusion we must note that the materials
have cited give mainly a static account of
zen humus-retention, in terms of humus pro-
s and the qualitative composition of the
nus, and that very little is said about the
chanism of the process. Partial attempts
e been made to explain this mechanism from
a (4 and 14) on the cryogenic migration of solutions in frozen soil materials. Therefore the concept of frozen humus-retention is provisional and must be verified and studied further. It may be possibly expanded and extended to cover available components in the mineral part of the soil as well as humus.

Received June 1, 1960

BIBLIOGRAPHY

1. ALEKSANDROVA, V.D. 1958. An attempt to determine tops and roots of plants in the Arctic tundra. Botanicheskiy zh., 63, No. 12.

2. ALEKSANDROVA, V.D. 1937. Tundras of the right bank of the Popigay. Tr. Arktich. in-ta, 63.

3. BARANOVSKAYA, A.V. 1952. Features of humus accumulation and composition in the soils of the Komi ASSR. Tr. Komi f-la Akad. Nauk SSSR, ser. geogr., No. 1.

4. BOZHENOVA, A.I. and F.G. BAKULIN. 1957. Experimental studies of the mechanisms of moisture migration in frozen soil materials. In: Materials on laboratory studies of frozen soil materials, 3.

5. GORODKOV, B.N. 1932. Permafrost in the Far North. Tr. SOPS Akad. Nauk SSSR, ser. severnaya, No. 1.

6. GORODKOV, B.N. 1932. Soils of the Gyda tundra. Tr. Polyarnoy kom. Akad. Nauk SSSR, No. 7.

7. IVANOVA, YE.N. 1952. Basic features of the soils along the Pechora Railroad. Tr. Komi f-la Akad. Nauk SSSR, ser. geogr., No. 1.

8. IVANOVA, YE.N. and N.A. KOPOSOV. 1937. Soils of the Khibin tundras, II. Tr. SOPS, ser. Kol'skaya, No. 13.

9. IVANOVA, YE.N. and O.A. POLYNTSEVA. 1936. The genesis of podzols with a humus-illuvial horizon on the weathered products of nepheline-syenites in the Khibin block. Probl. sov. pochv.

10. KREYDA, N.A. 1958. Soils of the East European tundras. Pochvovedeniye, No. 1.

11. LIVEROVSKIY, YU.A. 1934. Soils of the tundras of the Far North. Tr. Polyarnoy kom., No. 19.

12. PONOMAREVA, V.V. 1951. Humus-illuvial podzolization process. Uch. zap. Len. un-ta, No. 140(27).

13. PONOMAREVA, V.V. 1949. The reactions of fulvic acids with base hydro-oxides. Pochvovedeniye, No. 11.

14. TYUTYUNOV, I.A. 1951. Migration of water in a peat-gley soil when frozen, and the frozen state when permafrost lies close to the surface. Izdatel'stvo Akad. Nauk SSSR.

15. TSYTOVICH, N. A. 1957. Physical phenomena and processes in freezing frozen and thawing soil materials. In: Materials on laboratory studies of frozen soil materials, 3.

16. TEDROW and DREW. 1958. Major genetic soils of the Arctic slope of Alaska. J. Soil Sci., (9)1.

17. TEDROW and HILL. 1955. Arctic brown soi Soil Sci., 80(4).

SE OF SPRINKLING IRRIGATION IN RECLAMATION OF ANDY SOILS ON THE INCHAS FARM IN EGYPT

MED HAMAL ABD EL-SAMI, National Research Center of the UAR (Egypt)

In January 1957, a committee was set up by Ministry of Land Reform to study sprinkling igation on virgin desert lands adjacent to the has farm. The Desert Institute was asked to dy the soils and examine their salinization l chemical and physical properties. The l Department of the Institute subsequently died soil moisture and salinization during ts. The materials obtained are given in this er.

Location and Relief

The experimental plot covers approximately eddan (1 feddan = 1.04 acre) on an old desert race on the right side of the Nile River. The face is uneven and slopes from south to th. Absolute altitude is 17.5-24.5 m above sea level (Fig. 1). Ground water lies at a depth of 8 m.

Soils

When compiling a soil map we took 27 profiles 120-180 cm deep. Desert soils are mainly sandy in texture, with the coarsest sand in the upper layers and finer sand below. In some cases there are small quantities of clay and silt particles mixed with the sand.

The main differences in the soil profiles studied were in texture, the amount and nature of the salts, and the presence of gravel and pebble horizons (Tables 1 and 2, Fig. 2). The following types can be distinguished from these attributes:

Table 1

Results of chemical analysis of the soils[a]

Profile Number	Depth, cm	$CaCO_3$ to dry soil	pH	Analytical data for 1:1 water extract, %				
				Solid residue	CO_3^{--}	HCO_3^-	Cl^-	SO_4^{--}
1	0—30	2,27	8,5	0,041	Trace	0,013	0,006	0,007
	30—130	0,63	8,3	0,115	"	0,007	0,016	0,010
3	0—30	2,04	8,6	0,024	"	0,009	0,007	0,001
	30—80	0,67	8,1	0,165	"	0,006	0,040	0,060
	80—130	0,45	8,2	0,280	"	0,007	0,062	0,130
4	0—30	2,39	7,9	0,515	"	0,007	0,215	0,060
7	10—50	0,96	7,8	0,980	"	0,004	0,445	0,200
8	0—10	1,37	9,1	0,032	"	0,015	0,005	Not det'd.
	10—20	5,86	8,2	0,210	"	0,009	0,079	0,020
	20—70	8,50	7,9	0,810	"	0,005	0,346	0,240
21	0—15	1,21	8,4	0,097	"	0,009	0,011	0,050
	15—30	3,73	8,2	0,160	"	0,008	0,023	0,090
	30—60	2,39	8,1	0,482	"	0,005	0,070	0,260
	60—150	0,65	8,1	0,320	"	0,006	0,074	0,150

---

[a] Water extract results converted from parts per million to percentages.

Note: Comma represents decimal point.

1. Thick, friable sandy soils that do not contain either hard or stoney layers. No salt accumulation horizons. Some soils contain carbonate precipitates, sparsely distributed near the surface. These soils are found in low-lying areas and the depressions between hills where windborne sand accumulates (profiles 1, 5, 6, 9, 12 and 14). Analysis shows that they contain few salts and that they have a low capacity for water retention.

2. Profiles 3, 21, 24, 26, 27. Analyses of profiles 3 and 21 are given in Table 1. The sulfate content is quite high and increases with depth. Chlorides vary between 0.01% in the upper horizons to 0.07% in the lower horizons. The carbonate content is low and decreases with depth.

3. This type consists of sandy soils but differs from the first type in that there are layers of pebble or gravel. These horizons are quite thick and are found between 25-30 cm and 40-70 cm. They sometimes start as low as 60 cm and occasionally extend to a meter or below. The existence of gravel and pebble layers in the profile can affect the upward and downward movement of water, especially if irrigation is slight, as in sprinkling. However, their obstructive influence may decline after several years of irrigation as a result of the downward migration of fine soil particles and the effect of root systems. It should be noted that soils of this soil type have pebbles of various sizes at the surface.

4. Profiles 2, 4, 7, 8 and 13—sandy at the surface giving way to sandy loam deeper down. The thickness of the friable sandy horizon varies and the soils sometimes contain pebbles. The main difference between soils of this type and the others is that the central part of the profile is compacted. This portion is very hard and compact when dry, but is permeable and crumbles easily when moistened. The salt content is high and many of the salts are chlorides. The content of water-soluble salts varies between 0.2% and 0.98% and of chloride between 0.2% and 0.4%.

5. Soils of this type occupy only a small area (profiles 15, 18 and 19). They are somewhat similar to the soils of the second type, being sandy, thick, not very compacted, and with a medium content of salts (less than the fourth soil type). They are grey in color, owing to their relatively high content of silt and clay. These soils are found in depressions and on the lower parts of slopes. In profile 19 there is a 7-10 cm layer of clay at a depth of approximately 110 cm.

The distribution of all these soils is shown in Figure 2.

Irrigation

Irrigation water was pumped along a concreted irrigation channel from the Ismailia canal. At first we used a 40 hp pump. This pump operated from March to June in the first year but was then replaced, owing to frequent breakdowns, by a pump with 45 hp "International Centrifuge," which developed a pressure of

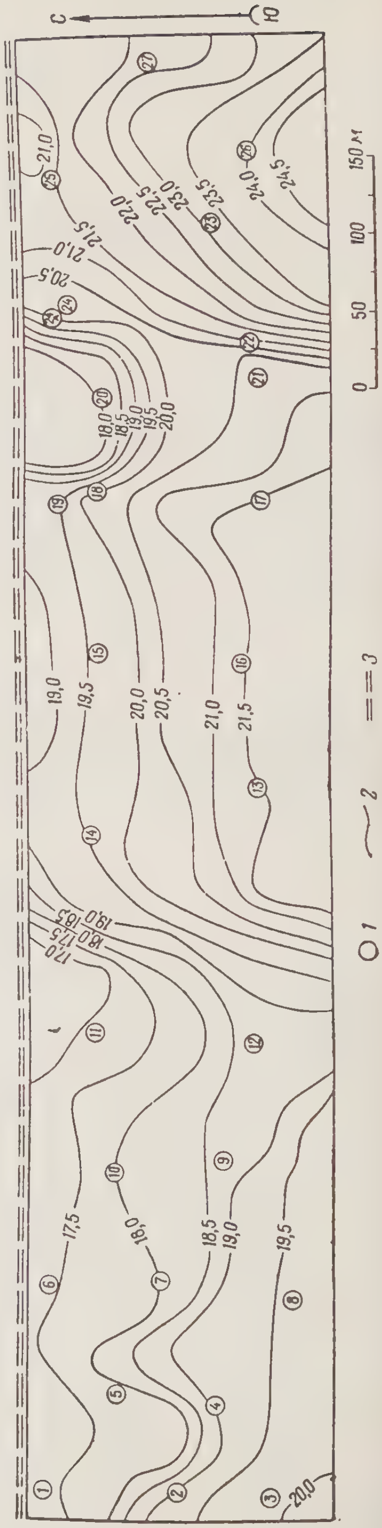


Fig. 1 - Topographic map showing location of soil profiles; 1 - soil profiles; 2 - contour lines; 3 - concrete irrigation channels.

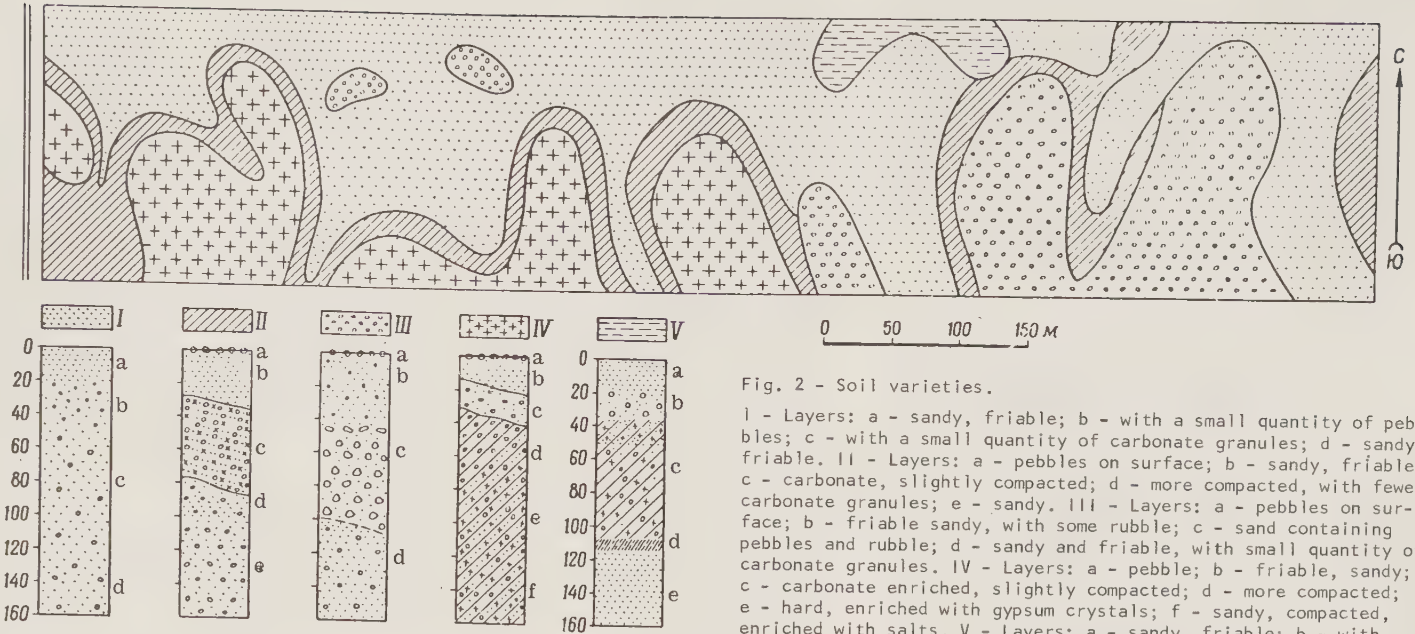


Fig. 2 - Soil varieties.

I - Layers: a - sandy, friable; b - with a small quantity of pebbles; c - with a small quantity of carbonate granules; d - sandy, friable. II - Layers: a - pebbles on surface; b - sandy, friable; c - carbonate, slightly compacted; d - more compacted, with fewer carbonate granules; e - sandy. III - Layers: a - pebbles on surface; b - friable sandy, with some rubble; c - sand containing pebbles and rubble; d - sandy and friable, with small quantity of carbonate granules. IV - Layers: a - pebble; b - friable, sandy; c - carbonate enriched, slightly compacted; d - more compacted; e - hard, enriched with gypsum crystals; f - sandy, compacted, enriched with salts. V - Layers: a - sandy, friable; b - with carbonate granules; c - sandy loam, compacted, contains salt crystals; d - clay; e - sandy.

Table 2

Particle-size analysis of soils

Profile Number	Depth, cm	% saturation of soil paste with moisture to an absolutely dry sample	Fractions obtained by dry sieving, %			
			Diameter of sand fractions, mm			
			>0.5 coarse	0.5-0.25 medium	0.25-0.125 fine	<0.125 very fine
1	0—30	17,2	23,6	25,5	29,4	21,5
	30—130	19,3	22,8	38,4	28,5	9,7
3	0—30	18,7	27,6	28,6	24,7	18,8
	30—80	30,7	32,1	32,5	24,1	9,7
4	0—30	29,4	21,8	35,0	25,8	18,1
7	10—50	46,0	50,5	29,5	15,2	4,4
8	0—10	18,8	28,7	17,2	25,3	28,3
	10—20	26,4	40,5	26,1	20,0	13,8
	20—70	49,3	47,3	28,5	16,1	8,0
21	0—15	21,4	26,7	26,6	28,9	17,5
	15—30	26,3	36,5	34,2	21,0	7,7
	30—90	40,2	16,6	40,6	34,2	8,0
	90—150	27,8	14,9	50,1	29,8	4,0

Note: Comma represents decimal point.

3.5-4 atm and had a capacity of 90 m³/hr. We used a portable sprinkler consisting of: 1) a main pipe 150 m long, 25 pipes 6 m long and 10.8 cm in diameter; and 2) five 150 m lateral pipes, consisting of tubes 6 m long and 7.9 cm in diameter, and 20 tubes 6 m long and 7.0 cm in diameter. The water was forced under pressure into the main pipe and channeled to the lateral pipes through T joints at 30 m intervals. Each branch pipe had fittings for 6 sprinkler nozzles, also 30 m apart. The effective operational radius of the nozzles was expected to be 23 m. The whole apparatus was made of aluminum and was intended to water 12.5 feddan. The location of the sprinkler nozzles and their successive positions on each 12.5 feddan are shown in Fig.3.

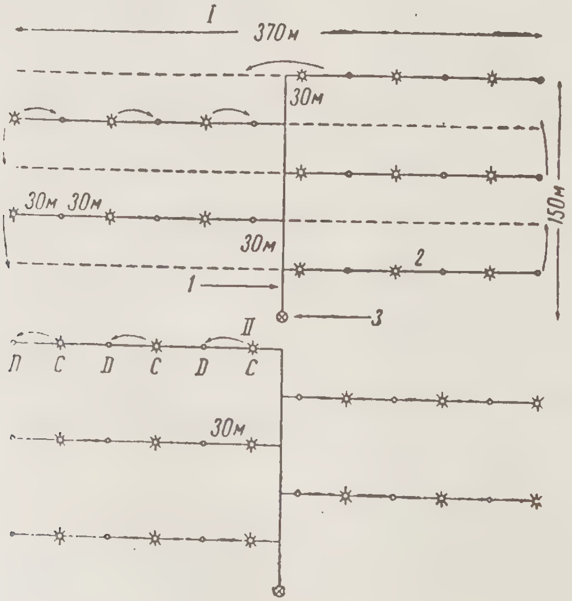


Fig. 3 - Diagram of sprinkler system and setting of pipes and nozzles.

I - Position A and B; II - Position C and D. 1 - main pipe; 2 - lateral pipe; 3 - pump.

e frequency and duration of irrigation was lows: 1) March 1957. Irrigation for 4 hr 3 days, increasing to 6 hr at the end of onth. 2) April—June. Field observations ed that the amount of water could be re- , so we began to irrigate for 6 hr, every s. The growth of citrus seedlings and crops in these months was satisfactory. rrigation in these three months gave 160 water per feddan every 6 days. 3) July— st. Owing to the increased temperature igher evaporation, irrigation was extended r every 6 days; each irrigation provided ³ of water per feddan. Plant growth was mely satisfactory. 4) September. Since mperature fell and humidity increased, ir- on time was reduced to 6 hr every 6 days. e were no signs of trees wilting. 5) er—November. Irrigation was reduced to every 6 days (110 m³ of water per feddan).

e main crop was citrus plants. Secondary were watermelons, sesame, beans, r, and peas. Various perennial grasses egumes (especially panicum and alfalfa) used in places as cover crops.

x points were selected in relation to the soil varieties and the features of the relief dy the water regime of the soils.

Methods of Analysis. a) Soil moisture was determined gravimetrically, samples were taken with an auger at 0-15, 15-30, 30-60 and 60-90 cm. b) Special tubes 20 cm tall and approximately 10 cm wide (Fig. 4) were placed on the surface between two branch pipes at set distances from the sprinkler nozzles to collect the water when determining the evenness with which the sprinklers distributed the water and the effect of wind and when measuring the amount of water to reach the ground. c) One of the main objections to the use of sprinkling on new lands is that desalinization from the root zone is inadequate. Samples were taken from 0-15, 15-30, 30-60 and 60-90 cm to follow the behavior of water-soluble salts. The salt content was determined by the conductometric method in a water extract (water: soil = 1:1); sulfates and chlorides were also determined. d) The moisture at wilting percentage was determined by the pressure-membrane technique; moisture equivalent was determined by centrifuge; the moisture saturation percentage of the soil paste was determined by saturation in laboratory cups.[1] The results obtained are shown in Tables 3 and 4.

Point	Soil variety	Location	
1	Second	Upper part of slope	westerly aspect
2	Fourth	Center part of slope	
3	First	Lower part of slope	
4	First	Upper part of slope	easterly aspect
5	Fourth	Center part of slope	
6	Fifth	Lower part of slope	

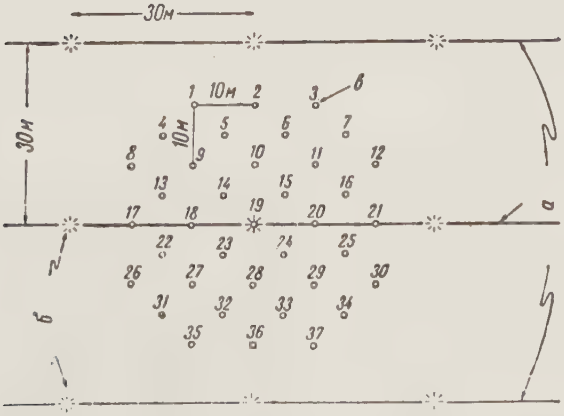


Fig. 4 - Location and numbers of collecting vessels among the sprinkling nozzles.

a - lateral pipes; b - sprinkler nozzles; c - collecting vessels.

---

[1] The procedure is described in: "Diagnosis and Improvement of Saline and Alkali Soils," U. S. Department of Agriculture Handbook, 1954.

Table 3

Results of physical analysis of soil

Point Number	Depth, cm	Bulk density, g/cm	% saturation of soil	Moisture equivalent, %	Wilting moisture, %	Available moisture	
						%	cm
1	0—15	1,75	23,0	2,8	1,7	1,1	0,29
	15—30	1,72	25,0	4,0	2,4	1,6	0,41
	30—60	1,72	31,0	8,2	4,4	3,8	1,96
	60—90	1,74	32,0	7,7	4,6	3,1	1,61
	Total						4,27
2	0—15	1,84	21,0	1,4	1,3	0,1	0,03
	15—30	1,77	29,0	5,9	3,0	2,9	0,77
	30—60	1,83	33,0	9,5	5,0	4,5	2,47
	60—90	1,82	36,0	10,0	5,2	4,8	2,62
	Total						5,89
3	0—15	1,67	21,0	2,0	1,4	0,6	0,15
	15—30	1,74	21,0	1,7	1,2	0,5	0,13
	30—60	1,77	21,0	1,7	1,2	0,5	0,13
	60—90	1,73	21,5	2,4	1,2	1,2	0,62
	Total						1,64
4	0—15	1,84	22,5	6,6	4,0	2,6	0,72
	15—30	1,87	31,0	5,8	3,1	2,7	0,76
	30—60	1,64	53,5	27,0	16,3	10,7	4,69
	60—90	1,57	60,0	30,3	19,6	10,7	5,04
	Total						11,21
5	0—15	1,58	41,0	16,8	9,3	7,5	1,78
	15—30	1,40	54,0	22,8	14,8	8,0	1,68
	30—60	1,44	62,0	24,2	15,4	8,8	3,80
	60—90	1,63	55,5	23,5	13,7	9,8	4,79
	Total						12,05
6	0—15	1,73	25,0	3,2	2,2	1,0	0,26
	15—30	1,73	25,0	3,4	1,9	1,5	0,39
	30—60	1,72	24,0	4,1	2,4	1,7	0,88
	60—90	1,69	22,0	3,6	2,2	1,4	0,71
	Total						2,24

Note: Comma represents decimal point.

Results and Interpretation

Soil Moisture. The results for the six points are given in Table 4. These figures show that the amount of water held by a 90 cm layer of soil increased from 302 m³/feddan at the beginning of the experiment to 564.5 m³/feddan by May 26.

Since there were 12 irrigations between March 23 and May 26 and the average irrigation was 160 m³/feddan, one would expect that the figure for moisture content in the soils would be not less than 12 X 160 + 302.8 = 2222.8 m³/feddan. The difference of 2222.8 - 564.5 = 1658.3 is connected with the following factors: a) the low efficiency of irrigation, owing to high evaporation and percolation of moisture to below 90 cm in the sandy soils; b) lower output from the pumps than their rated capacity; and c) plant moisture requirements.

The moisture content of the soils on June 26 was 644.3 m³/feddan or only 80 m³ more than a month previously (May 26), although approximately 800 m³/feddan had been given in 5 irrigations. The plants played an insignificant part in the utilization of the moisture, since their root systems were very poorly developed at that stage. Moreover, the samples were taken at a distance of 1 m from the seedlings, and therefo the moisture consumption was due to the first tw factors. Determination of moisture in the separate layers showed that at points 3 and 4 there wa less moisture in the first 60 cm on June 26 than on May 26; therefore irrigation had been inadequate in this period. At the close of the period the salt content in the layer increased; it is assumed that this was because of the upward movement of soil solutions.

Table 4

ount of moisture in 90 cm layer of soil in samples taken at various periods in 1957, compared with water constants

oint No.	Water constants of soils, amount of moisture, in cm				Amount of moisture, cm of water column			
	Wilting moisture	Moisture equivalent	Saturation percentage	Available moisture	March 23	May 26	June 26	Aug. 13
1	5,72	9,99	45,67	4,27	3,98	11,18	10,26	10,23
2	6,75	12,64	51,68	5,89	4,77	11,60	17,15	18,81
3	1,76	3,40	33,05	1,64	5,49	6,10	4,89	5,08
4	18,34	29,55	66,60	11,21	9,29	27,57	27,36	13,04
5	18,66	30,71	74,98	12,05	17,14	17,41	25,30	24,42
6	3,42	5,66	36,51	2,24	2,58	6,78	7,10	6,68
Total	54,65	91,55	308,09	37,30	43,25	80,64	92,06	78,26
Average	9,11	15,16	51,35	6,22	7,21	13,44	15,34	13,04
m^3 fedda	382.62	636,72	2156,70	216,20	302,80	564,50	644,30	547.70

Note: Comma represents decimal point.

Table 5

Changes in amount and distribution of irrigation water, cm^2

Irrigation on May 22, 23, 24				Irrigation May 31-June 2				Irrigation June 6, 7, 8			
No. of ollector	Volume	No. of collec.	Vol.	No. of collec.	Vol.	No. of collec.	Vol.	No. of collec.	Vol.	No. of collec.	Vol.
1	365	20	262	1	315	20	170	1	250	20	170
2	360	21	570	2	310	21	205	2	135	21	180
3	465	22	555	3	340	22	160	3	200	22	195
4	Trace	23	245	4	205	23	120	4	255	23	145
5	232	24	135	5	520	24	560	5	525	24	470
6	245	25	640	6	300	25	185	6	200	25	150
7	175	26	285	7	410	26	205	7	295	26	245
8	315	27	50	8	265	27	185	8	260	27	225
9	65	28	285	9	300	28	425	9	375	28	250
10	275	29	240	10	555	29	240	10	450	29	285
11	300	30	335	11	275	30	195	11	220	30	215
12	765	31	Trace	12	300	31	245	12	235	31	230
13	340	32	195	13	210	32	550	13	230	32	265
14	190	33	325	14	240	33	380	14	250	33	10
15	225	34	100	15	710	34	245	15	475	34	255
16	553	35	335	16	230	35	475	16	180	35	175
17	265	36	375	17	215	36	380	17	220	36	415
18	172	37	505	18	130	37	385	18	185	37	500
19	280	—		19	425	—		19	365	—	
Average			298				313				262

oisture content on August 13 was 547.7 m^3/ n. This amount is not in agreement with alue for water expended in irrigation. This e explained by: a) increased utilization of r by the citrus plants, and by the cover grasses and legumes; b) irrigating at night oid large losses from evaporation. The ir- ion was carried out with less care causing breakdowns which were not rectified by the workers; and c) increased surface evaporation in July and August.

Moisture determinations show that the moisture level was always high when soil samples were taken. This is confirmed by other methods (gypsum blocks and tensiometers).

Table 6

Comparison of actual amount of irrigation water and theoretical calculations for sprinkling irrigation in 1957

Date of Irrigation	Water accumulated in collectors, cm³	Quantity of irrigation water, cm	Quantity of water m³/feddan		Efficiency factor, %
			measured	theoretically calculated	
May 22-24	298	3,8	160,0	190	84
May 31-Jun2	313	4,0	168,0	200	84
June 8-10	262	3,3	138,5	200	69

Note: Comma represents decimal point.

The values in Table 4 show that the maximum available moisture which can be held by a 90 cm layer of the soil is 216 m³/feddan. The determinations of soil moisture show that this value is exceeded more than twice and sometimes more than three times. Therefore, the soils received more water than they could hold. This excess water should not be thought of as wasted, since it penetrated deep down, carrying with it salts from the soils. It should be mentioned that Nile clay and organic fertilizer was mixed with the sand in the holes in which the seedlings were planted. In the immediate vicinity of the seedlings the picture was, of course, somewhat different, but it remains true for the field as a whole.

Even Moisture Distribution. Moisture distribution was studied in 3 irrigations. The values are given in Table 5. They show that the amount of water in the collectors varies, firstly, in relation to the position of the collector relative to the sprinkler nozzle (Fig. 4) and, secondly, in relation to the direction of the wind. This factor was reduced in effect after the erection of a windbreak. Technical faults (inadequate pressure from the pump, etc.) also affected moisture distribution.

Efficiency. Table 6 shows the actual distribution of the water as revealed by the collectors and compares it with theoretical calculations based on the delivery of the pump.

It follows from Table 6 that the efficiency factor is quite high. The collectors thought, however, the water would reach the surface only and no allowance was made for possible surface runoff, since sandy soils are highly permeable.

Effect of Sprinkling on Removal and Distribution of Salts. Analytical data for the 6 points are given in Table 7. These values show: a) that there is a continuous decrease in the salt content to a depth of 90 cm. This shows that excess salts have been effectively removed from the sandy soils during sprinkling irrigation; b) that the various horizons in the profile reveal different changes in the salt content; c) that salts rise to the surface if irrigation is inadequate, especially in the hot summer months. On June 26, for example, there were more salts in the 0-15 and 15-30 cm layers at the first point than there had been a month previously (May 26). Th had been a corresponding decrease in the quanti of salts in the lower horizons as they rise to the surface. The extent of the capillary rise was n determined accurately, but the soil profile at th first point was fairly compact below 30 cm. It was shown that efficiency was only 69% at this time, and that soil moisture only exceeded the level of May 26, by 80 M³/feddan; d) that chlorides were leached from the profile more rapidly than sulfates; and e) it should be mentior that although there were less salts in the 0-15 c layer than in the 15-30 cm layer, there was a 1- cm crust at the surface which contained more salts.

We took the 0-60 cm layer as a basis for comparison in comparing leaching at the different points.

The results in Table 7 show that: 1) in May, after a month of irrigation, the content of salts had decreased to an equal extent at all points. Leaching had been greatest at point 1, followed by 4, 3, and 6; 2) in June there was a slight increase in salts at points 1, 2, 4, and 6 and a decrease at points 3 and 5; 3) in August there was a decrease at all points except 1 and 3; 4) in March, 5 months after starting irrigation, the content of residual salts had decreased to 7.5%-50% of their initial level; and 5) calculations of the variation in salinization for the layer down to 90 cm show that: a) at all 6 points salinization of the 0-15 cm layer had decreased least after a year of irrigation, b) leaching of salts ha been greatest from the 15-30 and 30-60 cm layers, c) after a year of sprinkling irrigation t residual salts were 15%-65% of their initial leve i.e., 35%-80% of the salts had been removed fro the 0-90 cm layer of the soils; 6) leaching was least at point 1 since it lay in a depression and received salt solutions filtered from more elevated sectors of the irrigated experiment plot; 7) Table 8 shows the total salt concentrations after a year of sprinkling irrigation.

Cost of Irrigation. Calculation was made monthly from March to October 1957. It consis of running costs of pump, cost of moving sprinklers, insurance, technical work (servicing), an various small items.

Average cost was 2.521 Egyptian pounds per fedden per month. This was much higher than

Table 7

Analytical data for water extracts (soil:water = 1:1), %

Point Number	Depth, cm	Before irrigation								After irrigation									
		total of salts			Cl			SO$_4$		total of salts					salts as % of initial level				
		Feb.	May	June	Feb.	May	June	Feb. 57	June	Feb.57	May	June	Aug.	Mar. 58	Feb. 57	May	June	Aug.	Mar. 58
1	0—15	0,0286	0,022	0,022	0,009	0,001	0,002	0,019	0,003	0,028	0,025	0,025	0,051	0,021	100	91	91	182	74
	15—30	0,360	0,022	0,035	0,135	0,002	0,005	0,058	0,003	0,360	0,022	0,035	0,018	0,015	100	6	10	5	4
	30—60	0,470	0,083	0,195	0,199	0,002	0,002	0,060	0,175	0,470	0,083	0,195	0,076	0,028	100	18	42	16	6
	60—90	0,470	0,180	0,162	Not det'd	0,001	0,002	Not det'd.	0,126	0,470	0,180	0,162	0,165	0,155	100	38	34	35	33
	Average	0,332	0,078	0,104	—	—	—	—	—	0,332	0,078	0,104	0,077	0,055	100	23	32	23	17
2	0—15	0,024	0,016	0,022	0,010	0,001	0,002	0,005	0,004	0,024	0,016	0,025	0,028	0,019	100	67	103	116	79
	15—30	0,150	0,016	0,032	0,047	0,002	0,002	0,033	0,007	0,150	0,016	0,032	0,022	0,016	100	11	22	15	11
	30—60	0,265	0,320	0,640	0,044	0,002	0,002	0,151	0,026	0,265	0,320	0,640	0,074	0,018	100	121	242	28	7
	60—90	0,265	0,180	0,195	Not det'd	0,002	0,002	Not det'd.	0,185	0,265	0,180	0,195	0,163	0,023	100	68	74	63	9
	Average	0,176	0,133	0,079	—	—	—	—	—	0,176	0,133	0,079	0,073	0,044	100	76	45	42	25
3	0—15	0,022	0,038	0,016	0,004	0,028	0,001	0,010	0,002	0,022	0,038	0,016	0,032	0,021	100	175	71	146	95
	15—30	0,066	0,019	0,016	0,010	0,002	0,002	0,028	0,003	0,066	0,019	0,016	0,020	0,014	100	29	24	31	21
	30—60	0,086	0,016	0,016	0,021	0,002	0,001	0,031	0,003	0,086	0,016	0,016	0,019	0,009	100	19	18	22	10
	60—90	0,036	0,022	0,016	Not det'd.	0,002	0,001	Not det'd.	0,002	0,086	0,022	0,016	0,017	0,013	100	26	18	20	15
	Average	0,065	0,025	0,016	—	—	—	—	—	0,065	0,025	0,016	0,022	0,014	100	39	24	34	22
4	0—15	0,086	0,019	0,038	0,007	0,002	0,003	0,013	0,015	0,086	0,019	0.038	0,026	0,062	100	22	45	30	72
	15—30	0,820	0,019	0,032	0,022	0,003	0,006	0,064	0,005	0,13	0,019	0,032	0,030	0,023	100	15	25	28	18
	30—60	1,050	0,215	0,525	0,408	0,004	0,003	0,214	0,358	1,050	0,215	0,525	0,039	0,043	100	21	50	37	41
	60—90	1,050	Не опр.	0,395	Not det'd.	0,004	0,018	Not det'd	0,182	1,05	Not det'd.	0,395	0,305	0,22	100	—	38	29	21
	Average	0,579	0,117	0,250	—	—	—	—	—	0,579	—	0,250	0,102	0,087	100	—	43	18	15
5	0—15	0,490	0,155	0,045	0,129	0,006	0,005	0,239	0,011	0,490	0,155	0,045	0,055	0,051	100	32	9	11	10
	15—30	1,960	0,295	0,22	0,032	0,003	0,004	0,231	0,101	1,960	0,295	0,226	0,165	0,21	100	15	11	8	11
	30—60	1,600	0,480	0,29	0,082	0,003	0,002	0,229	0,227	1,600	0,480	0,290	0,255	0,205	100	30	18	16	13
	60—90	1,600	0,480	0,510	Not det'd.	—	0,003	Not det'd.	0,382	1,600	Not det'd	0,510	0,430	0,305	100	—	32	27	19
	Average	—	—	—	—	—	—	—	—	1,412	—	0,266	0,226	0,195	100	—	19	17	14
6	0—15	0,052	0,022	0,025	0,004	0,002	0,002	0,022	0,014	0,052	0,022	0,025	0,023	0,032	100	42	49	44	61
	15—30	0,110	0,068	0,18	0,009	0,002	0,002	0,084	0,207	0,110	0,068	0,180	0,090	0,029	100	62	164	82	27
	30—60	0,205	0,180	0,016	0,019	0,002	0,002	0,174	0,157	0,205	0,080	0,18	0,155	0,130	100	39	88	76	63
	60—90	0,205	0,155	Not det'd.		0,001	0,002	Not det'd.	0,164	0,205	0,155	0,128	0,140	0,178	100	76	63	68	87
	Average	—	—	—	—	—	—	—	—	0,143	0,106	0,061	0,102	0,092	100	74	43	71	65

Note: Comma represents decimal point.

Table 8

Salt content in soils, %

Point No.	Mean content of salts in soil layer					
	60 cm			90 cm		
	initial	after one year's irrigation	salts remaining, as a % of initial level	initial	after one year's irrigation	salts remaining, %
1	0,286	0,021	7,5	0,332	0,055	16,5
2	0,146	0,018	12,3	0,176	0,044	25,2
3	0,058	0,014	25,0	0,065	0,014	21,8
4	0,425	0,043	10,1	0,579	0,087	15,0
5	1,350	0,158	11,7	1,412	0,195	13,8
6	0,1223	0,064	52,3	0,143	0,092	64,8

Note: Comma represents decimal point.

ordinary irrigation in the Nile delta, owing to the high cost of servicing the pumps and the lack of trained workers for sprinkling. The major part of the expenditure was the cost of the pump. Other expenses are gradually reduced as experience in the use of sprinkling apparatus is acquired.

Conclusions

The article has shown that new desert sandy soils of the ancient Nile terrace can be brought into cultivation and has given a general description of them. It has been shown in other countries, and under other conditions, that the sprinkling irrigation can be used with success. The method has many advantages over ordinary gravity flow irrigation, but such irrigation is quite expensive in the United Arab Republic owing to the high cost of the equipment. Although the results are provisional, the following conclusions can be drawn.

1. Differences in elevation of up to 5 m in 50 feddan do not need to be levelled out when irrigating by sprinkler.

2. The sprinkling system can provide the amount of water needed for plant growth and to leach excess salts out of the soil profile. In some horizons 90% of the initial quantity of salts was removed in a single year.

3. The efficiency of the system is higher than 80%. This is an important factor for the irrigation of sandy soils under arid conditions.

4. Sprinkling makes more economical use of irrigation waters than the usual method, since the irrigation levels are 110-120 m^3/feddan.

5. Seedlings and temporary cover crops grow well when sprinkling is used.

6. Irrigation was quite costly in the first 8 months owing to frequent breakdowns (2.5 Egyptian pounds per feddan per month). The cost was reduced as experience was acquired.

Received June 20, 1960

E ROLE OF SHRUB ROOTS IN SUPPLYING SOIL ITH ORGANIC MATTER AND NITROGEN

P. POKHITON, Botanical Gardens, Ukrainian Academy of Sciences, Kiev

ystematic study of the organic matter in
 was started by Kostychev (8), who laid a
s for the biological trend in soil science.
s line of research was successfully con-
ed by Krakov (9), who studied mainly the
ay processes of plant residues in the soil and
part played by dead organic litter-fall in
 formation. He established that the accumu-
on of humus in the soil and its composition
end on the amount and quality of the plant
dues reaching the soil and on the properties
ne mineral part of the soil.

Tyurin (21), investigating forest soils,
blished that secondary forms of organic
 matter are due mainly to plant-root resi-
s. He regards the role of surface litter as
sidiary and insignificant; while it plays an
oubted part in forming the upper soil hori-
 of the forest, it is much less important in
process of humus formation in the mineral
zons.

ubsequent research showed that some soils
upied by forest plantations are distinguished
 high organic matter content (4, 5, 6, 12, 13,
15, 16, 17, 20). Interesting experimental
k in this direction has been done by Zonn
 Orlov (11), and Mina (10); these workers
blished the accumulation of organic residues
 a definite period of time and determined
contents of ash element and nitrogen in soil
er forest. They did not, however, adduce
 on the humus accumulation in soil as a re-
 of the influence of tree root vegetation.

Our investigations were made on material
n the Botanical Gardens of the Ukrainian
demy of Sciences in 1957 and 1958. The
eral geomorphological, soil, and climatic
ditions of the Botanical Gardens have been
cribed in detail in papers by Vernander (1),
Shiman (22), and we need only mention that
shrubs selected for study grow in certain
s of the Botanical-Geographical "Ukrainian
land Forest" group. The shrubs grow in
ups and their growth is not noticeably influ-
ed by vegetation at other levels. The age of
shrubs varies from 8 to 14 years.

oil samples for analysis were taken at the
e time as monoliths with a 0.5 x 0.5 m
ion for determining root content in them.
 samples were taken from each profile:
from the 20-30 cm soil layer (one in the
root zone, the other outside it), two from the 60-70 cm layer, and one from the 0-10 cm layer. We regarded the latter as having been taken from the root zone since the top soil layer is so saturated with roots that it was impossible to take a sample of it outside the root zone. The soil samples taken outside the root zone were used as controls. Special care was taken in preparing the soil samples for analysis, to get a complete selection of plant residues.

The following values were determined: humus content (Tyurin method), water-soluble organic matter (Kubelyu-Timan), total nitrogen (Kjeldahl), and protein nitrogen (Bernstein).

The data shown in Table 1 point to a marked increase in humus content in the root zone of soil under shrub vegetation. The quantity of extra humus content depends both on the shrub species and on the soil.

As an example of how the shrub species influences the organic matter content in the soil we may take the red dogwood and common buckthorn, which grow close together in the same soil. Both shrubs develop a thick root system but the buckthorn has smaller roots: 1360 g/m² of small buckthorn roots were measured in the 90 cm layer against 478 g/m² of dogwood roots, a difference of nearly two-thirds. One would therefore expect the humus increment in the root zone of the soil under buckthorn to be correspondingly higher than that in the soil under dogwood.

The analysis data show, however, that the humus increment in the 20-30 cm layer under dogwood was very high—133.5%, against only 18.0% in the soil under buckthorn. The relatively small humus increment in the buckthorn root zone can be explained by the higher humus content in the soil outside the root zone (2.05%-2.64%), as compared with the same zone under dogwood (1.55%-0.46%). The high humus content in the soil under buckthorn is a result of the intensive root development there and the considerable saturation of the soil with roots.

The direct connection between the amount of humus increment in the root zone soil and its root-saturation can be illustrated by the values for humus content in soil under European cranberry bush and common barberry, growing side by side in the same type of soil. The cranberry

Table 1

Influence of shrub roots on humus content in soil[a]

Shrub	Soil	Depth, cm	Humus, %			
			in root zone	outside root zone	difference	humus increment in root zone
Dogwood	Podzolic sandy loam developed on old alluvial deposits	0—10	4,60	—	—	—
		20—30	3,62	1,55	2,07	133,5
		60—70	0,66	0,46	0,20	43,5
Common buckthorn	Podzolic sandy loam developed on old alluvial deposits	0—10	3,08	—	—	—
		20—30	2,42	2,05	0,37	18,0
		60—70	3,09	2,64	0.45	17.0
Tatar honeysuckle	Light grey forest eroded soil developed on loess	0—10	3,62	—	—	—
		20—30	2,28	1,38	0,90	65,2
		60—70	0,70	0,21	0,49	233,3
Cornelian cherry	Light grey forest soil over buried soil	0—10	2,70	—	—	—
		20—30	1,73	1,18	0,55	46,6
		60—70	0,82	0,69	0,13	18,8
Cherry plum	Grey forest soil developed on loess	0—10	4,60	—	—	—
		20—30	2,27	1,40	0,87	62,1
		60—70	0,64	0,52	0,12	23,1
Mock orange	Grey forest soil developed on loess	0—10	3,89	—	—	—
		20—30	3,21	2,68	0,53	19,8
		60—70	1,76	0,83	0,93	112,1
Ninebark	Grey forest soil developed on loess	0—10	3,06	—	—	—
		20—30	2,27	2,09	0,18	8,6
		60—70	—	1,07	—	—
Rose	Grey forest soil developed on loess	0—10	2,91	—	—	—
		20—30	2,59	1,60	0,99	61,9
		60—70	0,84	0,67	0,17	25,4
Privet	Grey forest soil developed on loess	0—10	2,78	—	—	—
		20—30	2,12	0,98	1,14	116,3
		60—70	0,92	0,52	0,40	76,9
Blackthorn	Sod-clay developed on clay	0—10	6,79	—	—	—
		20—30	5,50	4,45	4,05	16,9
		60—70	Not det'd.			
Single-seed hawthorn	Sod-podzolic sandy loam developed on alluvial-deluvial deposits	0—10	4,98	—	—	—
		20—30	4,62	4,05	0,75	14,1
		120—130	1,56	1,56	0,00	0,00
Common barberry	Transitional from eroded leached chernozem to dark-grey forest eroded	0—10	2,38	—	—	—
		20—30	1,21	1,00	0,21	21,0
		60—70	1,00	0,73	0,27	37,0
European cranberry bush	Transitional from eroded leached chernozem to dark-grey forest eroded	0—10	2,27	—	--	—
		20—30	2,33	1,08	1,25	115,7
		60—70	0,80	0,59	0,21	35,6

---

[a] All analyses were made by the author in the soil entomology laboratory of the Institute of Plant Protection, Ukrainian Academy of Agriculture, which was kindly put at his disposal.

Note: Comma represents decimal point.

Table 2

Influence of plant roots on content of water soluble organic matter in the soil

Shrub	Soil	Depth, cm	Water-soluble organic matter mg C/100 g soil			
			in root zone	outside root zone	difference	humus increment in root zone
Dogwood	Podzolic sandy loam	0—10	35,10	—	—	—
		20—30	35,10	28,08	7,08	25,0
		60—70	19,20	8,64	10,57	122,3
Common buckthorn	Podzolic sandy loam	0—10	42,16	—	—	—
		20—30	33,36	29,84	3,52	11,8
		60—70	31,60	28,08	3,53	12,6
Tatar honeysuckle	Light grey forest	0—10	35,04	—	—	—
		20—30	36,88	26,32	10,56	40,1
		60—70	17,44	10,40	7,04	67,7
Cornelian cherry	Light grey forest	0—10	36,88	—	—	—
		20—30	26,32	19,20	7,12	37,1
		60—70	13,92	8,64	5,28	62,3
Cherry plum	Grey forest	0—10	38,64	—	—	—
		20—30	28,08	21,12	6,96	33,0
		60—70	13,92	10,40	3,52	33,8
Mock orange	Grey forest	0—10	36,88	—	—	—
		20—30	40,40	36,88	3,52	9,3
		60—70	21,04	12,16	8,88	73,1
Ninebark	Grey forest	0—10	31,60	—	—	—
		20—30	23,56	19,28	4,28	22,2
		60—70	—	15,68	—	—
Rose	Grey forest	0—10	36,88	—	—	—
		20—30	29,84	23,76	6,08	25,6
		60—70	12,16	10,40	1,76	17,0
Privet	Grey forest	0—10	22,80	—	—	—
		20—30	21,04	19,20	1,84	9,6
		60—70	8,64	6,88	1,76	25,6
Blackthorn	Sod clay	0—10	82,65	—	—	—
		20—30	65,04	58,00	7,04	12,1
		60—70	Not det'd.			
Single-seed hawthorn	Sod podzolic sandy loam	0—10	38,64	—	—	—
		20—30	35,10	29,84	5,26	17,6
		120—130	26,32	18,20	8,12	44,7
Common barberry	Transition from eroded leached chernozem to dark-grey forest eroded	0—10	26,32	—	—	—
		20—30	24,50	15,68	8,88	56,0
		60—92	13,92	12,08	1,84	15,2
European cranberry bush	Transition from eroded leached chernozem to dark grey forest eroded	0—10	28,08	—	—	—
		20—30	35,10	19,28	15,82	81,5
		60—70	15,68	12,08	3,60	29,8

Note: Comma represents decimal point.

sh, in addition to developing a thick root system (727 g/m² in the 90 cm soil layer) gives a gh humus increment in the root zone at a depth of 20-30 cm (115.7%), whereas in the soil under barberry bush, where the root content is low (66 g/m²) the humus increment is found to be

Table 3

Influence of shrubs on nitrogen content in the soil

Shrub	Soil	Depth, cm	Total nitrogen in percent			
			in root zone	outside root zone	difference	humus increment in root zone
Dogwood	Podzolic sandy loam	0—10	0,217	—	—	—
		20—30	0,172	0,070	0,102	145,8
		60—70	0,040	0,027	0,013	48,2
Common buckthorn	Podzolic sandy loam	0—10	0,191	—	—	—
		20—30	0,140	0,124	0,016	12,9
		60—70	0,162	0,145	0,017	11,7
Tatar honeysuckle	Light grey forest	0—10	0,211	—	—	—
		20—30	0,144	0,94	0,050	53,2
		60—70	0,049	0,031	0,018	58,1
Cornelian cherry	Light grey forest	0—10	0,153	—	—	—
		20—30	0,101	0,062	0,039	63,0
		60—70	0,051	0,036	0,015	41,7
Cherry plum	Grey forest	0—10	0,204	—	—	—
		20—30	0,132	0,085	0,047	55,3
		60—70	0,043	0,03	0,004	10,3
Mock orange	Grey forest	0—10	0,211	—	—	—
		20—30	0,176	0,141	0,035	24 8
		60—70	0,110	0,048	0,062	129,0
Ninebark	Grey forest	0—10	0,157	—	—	—
		20—30	0,122	0,116	0,006	5,2
		60—70	—	0,06	—	—
Rose	Grey forest	0—10	0,169	—	—	-
		20—30	0,169	0,077	0,096	124,7
		60—70	0,056	0,045	0,011	24,5
Privet	Grey forest	0—10	0,155	—	—	—
		20—30	0,115	0,049	0,066	134,7
		60—70	0,043	0,017	0,026	153,0
Blackthorn	Sod clay	0—10	0,408	—	—	—
		20—30	0,329	0,240	0,089	37,1
		60—70	Not det'd.			
Single-seed hawthorn	Sod podzolic sandy loam	0—10	0,232	—	—	—
		20—30	0,247	0,201	0,046	22,9
		120—130	0,067	0,063	0,004	6,4
Common barberry	Transition from eroded leached chernozem to dark-grey forest eroded	0—10	0,144	—	—	—
		20—30	0,076	0,057	0,019	33,4
		60—70	0,060	0,048	0,012	25,0
European cranberry bush	Transition from eroded leached chernozem to dark-grey forest eroded	0—10	0,179	—	—	—
		20—30	0,142	0,069	0,073	105,8
		60—70	0,048	0,042	0,006	14,3

Note: Comma represents decimal point.

low too (21.0%).

At a depth of 60-70 cm the humus increment in the root zone soil under cranberry is 35.6%, against 37.0% under barberry. The similarity between the two values, despite differences in the root saturation of the soil under the two different shrubs, apparently is due to the influence of other biotic factors, in particular the activity of earthworms (2, 3, 7).

It is not open to question that humus accumu- ion in the root zone of soil is due to the ivity of plants. The humus source may be aying root hairs, feeding roots and to some ent vascular roots, as Orlov has shown (11). other important humus source is organic and ganic-mineral matter secreted into the soil by e roots, as we can see from the values for ter-soluble organic matter given in Table 2, ich show that the soil in the shrub zone con- ns more of this than the soil outside the root ne.

No clear relationship can be detected between e amount of the increment in water-soluble or- nic matter, and the shrub species and root- turation of the soil, or the total amount of mus increment (Tables 1 and 2). The highest rcentage increment of water-soluble organic tter in the root zone soil was found under rubs growing in soil transitional between oded leached chernozem and dark-grey forest il on loess (cranberry, barberry) and the vest percentage increment in the soil under rubs in podzolic sandy loam on fluvioglacial posits (dogwood, buckthorn), grey forest soil loess (ninebark, rose, privet) and sod-clay il on clays (blackthorn).

The considerable range and variation of ter soluble humus content in soils must be e to the presence, in the plant root zone, of rge masses of microorganisms which use the ganic soil matter as energy material for their n activity. This conclusion is based on the dings of Samtsevich and Katerinich (18, 19) o established that root secretions amounting all to 5%-10% of the root weight are continu- sly taken up by microorganisms in the rhizo- here.

The values for total nitrogen content (Table can be taken as indicating the active influence shrub root systems on the soil.

The greatest nitrogen increment in the root ne in the 20-30 cm soil layer occurs under d dogwood (145.8%), European cranberry)5.8%), and Cornelian cherry (63.0%). Under ner shrubs (cherry plum, blackthorn, bar- rry) the nitrogen increment in the root zone is aller (55.3%-22.9%) and sometimes (buck- orn, ninebark) very small (12.9%-5.2%).

In the 60-70 cm layer considerable nitrogen crement has been found in the root zone under ivet (153.0%), mock-orange (129.0%), honey- ckle (58.1%), and dogwood (48.2%). In soil der shrubs the nitrogen increment in the root ne varies at this depth from 41.7% under rnelian cherry to 6.4% under hawthorn.

Sources of nitrogen in the soil are organic tter from plant residues and soil microor- nisms and invertebrates in the root zone.

The data on soil humus and nitrogen content the root zone under shrubs justify the con- sion that living organisms play an immense rt in the soil formation process and in en- ncing the potential fertility of the soil. ants, microorganisms and soil invertebrates cumulate and retain in their bodies large ounts of ash element and nitrogen, protecting m from being dissolved and leached into the deep layers of the soil and into the soil-forming parent material outside the main plant root zone.

These elements are only gradually released from the dead plant residues and the bodies of the organisms. A part, however, consisting of products of the roots' activity, continuously fill up the soil with nutrients in a form available to plants.

Conclusions

1. Shrub vegetation actively causes organic matter and nitrogen to accumulate in the root-zone soil. The amount of accumulation depends on the shrub species and on the saturation of the soil with roots, as well as on the soil type.

2. The humus increment in the root zone sharply increases under shrubs which provide maximum saturation of the soil with small roots. The highest percentage of humus increment is observed in podzolic sandy loam and the lowest sod-podzolic sandy loam and dark grey forest soils.

3. In soil under shrubs, dying roots as well as the roots of herbaceous vegetation penetrating the soil under the shrub canopy, and also the surface litter-fall, can be sources of organic matter. Root secretions also seem to be of great importance.

4. No clear relationship has been detected between the increase in the content of water-soluble organic matter in the root zone of soil under shrubs and the shrub species and saturation of the soil with roots.

5. Nitrogen accumulation in the shrub root zone of soils occurs primarily in protein form. Humic substances, organic and mineral root secretions and soil microorganisms and invertebrates can be sources of nitrogen in soil under shrubs.

6. The possibility of enriching the soil with organic material and nitrogen by an appropriate selection of shrub vegetation and by adjusting the composition of existing shrub plantations opens up new opportunities for enhancing the yield of plantations for industrial and special purposes such as soil and field protection, melioration, water conservation, decoration and display.

Received March 18, 1959

BIBLIOGRAPHY

1. VERNANDER, N. B. 1946. Soil research at the Botanical Gardens of the Ukrainian Academy of Sciences. Scientific report. Kiev.

2. GILYAROV, M. S. 1947. Distribution of humus, root systems and soil invertebrates in walnut forest soil on the Fergana range. Dokl. Akad. Nauk SSSR, 55(1).

3. GILYAROV, M. S. 1951. The role of soil animals in forming the soil humus layer.

Uspekhi sovr. biol., vol. XXXI, vyp. 2.

4. GORSHENIN, K. P. 1924. Influence of forest plantations on the chemical and morphological structure of chernozems. Pochvovedeniye, No. 3-4.

5. ZOLATAREV, S. A. 1957. The role of forest in soil formation, and forest soil groups. Nauchn. tr. Ukr. s.-kh. akademii vol. IX, Kiev.

6. ZONN, S. V. 1954. Influence of forest on soil. Izd. Akad. Nauk SSSR.

7. ZRAZHEVSKIY, A. I. 1957. Earthworms as a factor in forest soil fertility. Izd. Akad. Nauk USSR, Kiev.

8. KOSTYCHEV, P. A. 1949. Soils of the chernozem region of Russia, their origin, composition, and properties. Gos. izdat. s.-kh. literatury.

9. KRAVKOV, S. P. 1937. Soil science. 2nd edition. Leningrad.

10. MINA, V. N. 1955. Nitrogen and ash element circulation in forest steppe oak stands. Pochvovedeniye, No. 6.

11. ORLOV, A. YA. 1955. The role of tree feeding roots in enriching the soil with organic matter. Pochvovedeniye, No. 6.

12. POGREBNYAK, P. S. 1948. The role of roots and organic leaf-fall in the genesis of forest steppe soils. Dokl. Akad. Nauk USSR, No. 2.

13. POGREBNYAK, P. S. 1949. The investigation of soils and roots systems in forests. Pratsi In-tu lisivnitstva Akad. Nauk URSR, vol. 1.

14. POKHITON, P. P. 1952. The connection between forest plantations and soils. Large scale afforestation and the raising of planting material. Tr. Respubl. konfer. po vopr. razvitiya stepnogo lesorazved. USSR. Izd. Akad. USSR, Kiev.

15. POKHITON, P. P. 1957. Influence of trees and shrubs on the physical and chemical properties of chernozem soil. Pochvovedeniye, No. 3.

16. POKHITON, P. P. 1957. Distribution of plant and shrub roots in chernozem soil. Gossel'khozizdat, USSR.

17. POKHITON, P. P. 1958. The influence of various trees on soil. Pochvovedeniye, No. 6.

18. SAMTSEVICH, S. A., and T. D. KATERINICH. 1953. Variation in organic matter in southern chernozem under the influence of oak plantations. Pochvovedeniye, No. 4.

19. SAMTSEVICH, S. A. 1958. The interrelationships between microorganisms and higher plants. Voprosy pochvennoy mikrobiologii, II. Tr. In-ta mikrob. Akad. Nauk LatvSSR. vyp. VII, izd. Akad. Nauk LatvSSR, Riga.

20. TKACHENKO, M. YE. 1939. The influence of rocks on soil. Pochvovedeniye, No. 10.

21. TYURIN, I. V. 1946. The quantitative participation of living matter in the composition of the organic part of soil. Pochvovedeniye, No. 1.

22. SHIMAN, L. M. 1958. A brief physical-geographical description of the botanical gardens of the Ukrainian Academy of Sciences. Kiev.

MATOMELANIC ACIDS OF FOSSIL COALS

. KUKHARENKO and L. N. YEKATERININA, Institute of Fuel Minerals, Academy of
ces, USSR

ymatomelanic acids, which constitute an ol-soluble fraction in the humic acids of and fossil coals, have been studied little. rat'yev (1), and Kukharenko (3) isolated lescribed hymatomelanic acids from peats rown earth coals without indicating their n. According to these authors' findings the tomelanic acids are more reduced. As ared with humic acids[1] the composition of hymatomelanic acids given by Ssyskoff (9), 'uchs (10) indicate high oxidation in com- on with humic acids. Tyurin, studying rganic matter in soils (7), expresses the on that hymatomelanic acids are both more ced and more oxidized derivatives of humic . After Fuchs had separated hymato- nic acids from oxidized nitric acid in coal etermined their molecular weight ebul- opically in acetone as 800-900, the above- ioned authors worked out the formulae for acids on the basis of experimental data, eeding from these numbers without any at- t to determine the molecular weight.

e found that in hard coals bedded near the ce, alcohol-soluble acids form which are ar to the hymatomelanic acids of peats oils. Hard coals do not of course contain c acids; under the influence of metamor- s they have been converted into more com- neutral substances. The formation of c acids in them under the influence of n and moisture is therefore regarded as tion-hydrolytic destruction, accompanied e formation of acids from high molecular c to low molecular acids and also to carbon and water, as intermediate products.

e investigation of hymatomelanic acids as etic products from dead plant residues, lso as destruction products formed under fluence of metamorphism of humic mat- s important for our knowledge of the e and origin not only of hard fossil fuels so of soils, where it is more difficult to guish the processes by which humic sub- es are synthesized from the processes by which they are destroyed, than in the case of solid mineral fuels.

For the investigations we took vitrinized hard Kuzbass coals oxidized under natural conditions, at various stages of metamorphism: 1) gas coal from the Leninsk deposits, Gramoteinsk pit, Baykaimsk seam; 2) soft coal from the Karagaylinsk deposit, Rytvinn seam, incline No. 27; 3) lean coal from the Bunguro-Listvyansk deposit, Bungursk tunnel, No. 2 seam. To study how far the intensity of weathering influences the production and composition of acids, we selected the test samples at various depths below the surface. For comparison, hymatomelanic acids from the topmost peat of the Elektroperedach mine and Aleksandriysk brown earth coal were also extracted.[2] To find out whether it was possible for hymatomelanic acids to form as a result of the breakdown of humic acids we separated the soluble acid fraction after breaking down the humic acids of a soft vitrainized coal (Baydayev shaft, seam 14) with metallic sodium under conditions described by us in an earlier paper (4).

The original plan had been to separate the hymatomelanic acids by extraction with ethyl alcohol followed by washing with alkali hydroxide. On comparing the composition of the hymatomelanic acids before and after washing we found that washing was essential, since ester formations occurred to some extent:

	C%	H%	OCH_3	COOH	OH
Before washing	66.85	4.16	1.75	4.28	1.75
After washing	67.85	3.65	1.05	4.83	1.05

It was found, however, that when the composition of the unseparated humic acids were compared with that of the alcohol-soluble and alcohol-insoluble fractions extracted (Table 1) prolonged heating with alcohol and then with alkali led to a change in the composition, the carbon and hydrogen content in the fractions proving higher than in the original acids.

---

[1] en's terminology has been used here, as we do nk it would be possible to bring the terminology nt among coal chemists into line with that used l scientists without detailed discussion.

[2] The test samples were kept in the laboratory for several years.

Table 1

Composition of alcohol-soluble and alcohol-insoluble fractions of humic acids

Preparation	C	H	Content of active acid groups, meq/g		
	%		Total	Carboxyls	Phenol hydroxyls
Humic acids of weathered bituminous Kuzbass coal, Zenkovsk inclines:	64,99	2,82	6,15	4,04	2,11
a) alcohol-soluble part	65,35	3,65	6,80	4,83	1,97
b) alcohol-insoluble part	67,36	3,22	6,52	4,23	2,29
Humic acids of Kuzbass coal, Maneikh shaft:	65,70	2,66	7,25	3,56	3,69
a) alcohol-soluble part	61,38	3,48	6,93	4,68	2,25
b) alcohol-insoluble part	65,97	3,18	5,26	3,82	1,44

Note: Comma represents decimal point.

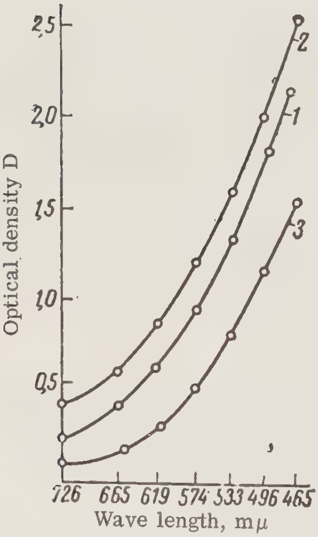


Fig. 1. - Optical density of 0.02% alkaline solutions of humic acids from weathered soft hard coal (Maneikh shaft) and their fractions

1 - humic acids; 2 - fraction insoluble in dioxane and alcohol; 3 - fraction soluble in dioxane and alcohol.

It had been previously shown that dioxane dissolves part of the humic acids (5) and, moreover, is a convenient cryoscopic solvent for a fraction soluble in it (6). Hymatomelanic acids extracted with alcohol were completely soluble in dioxane; conversely those extracted with dioxane were completely soluble in alcohol; the optical densities of their alkaline solutions were identical. When the composition of the acids extracted with one or the other solvent were compared a certain similarity was observed (Table 2); the only exception was the nitrogen content which was higher in the preparations extracted with dioxane.

The hymatomelanic acids were extracted in the following way. First the bitumens were extracted from the coal with benzol.[3] Next, the humic acids were extracted from the residue with a tenth normal solution of sodium hydroxid after precipitating with hydrochloric acid and washing the humic acids, they were brought to air-dry condition and extracted with dioxane in a Soxhlet apparatus. After the dioxane had bee distilled the hymatomelanic acids were dried to constant weight in a vacuum drier. As the curves in Figure 1 show, the optical density of the alkaline solutions of the dioxane-soluble fraction was lower than that of the dioxane-insoluble fraction.

The optical density curve of the humic acids which were not broekn down into fractions lies between the curve for the two fractions.

Elementary analysis, content of methoxyl an active acid groups, molecular weight cryoscopi ly in dioxane, and optical density of the 0.02% alkaline solution were determined in the sampl obtained. For comparison we have given the humic acid composition of the same coals.

As Table 3 shows, in certain weathered har coals the hymatomelanic acid content reaches a high value, as was noted first. The appearanc of these acids can be explained mainly as a result of the breakdown of the aromatic nucleus o the humic acids formed at an earlier stage of oxidation, under natural conditions, of the neutral humic substance in hard coals. The mechanism of this breakdown of the aromatic nucleus is explicable in terms of the theory of oxidation-hydrolytic breakdown of organic compounds developed by Shemyakin and Shchukina (

---

[3] The peat and brown earth coal were pretreated with boiling water and 5% hydrochloric acid, then washed and dried to air-dry condition.

Table 2

Comparison between hymatomelanic acids extracted with ethyl alcohol and extracted with dioxane

Acids of weathered hard coal Kuzbass—Maneikh, 3 m from roof)		C	H	N	OCH_3, meq/g	Active acid groups, meq/g	
		in %				Carboxyls	Hydroxyls
Extracted with ethyl alcohol	Hymatomelanic	60,94	4,40	0,97	1,75	5,10	2,65
	Humic	61,96	3,31	1,31	—	3,71	2,09
Extracted with dioxane	Hymatomelanic	60,26	4,44	1,42	1,38	4,44	2,09
	Humic	61,30	3,44	1,90	—	3,30	1,66

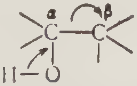
Note: Comma represents decimal point.

Table 3.

Yield of humic and hymatomelanic acids from various solid fossil fuels on dry and ash-free material

Source	Humic acids, % O. M.	Hymatomelanic acids as % of	
		Humic acids	Coal or peat
Peat	13,1	8,3	1,1
Brown earth coal	44,2	5,9	2,6
Weathered hard coals			
Gas, 4.5 m from surface	71,3	17,0	12,1
Gas, 5.0 m from surface	76,4	17,3	13,2
Gas, 9.0 m from surface	30,2	31,4	9,5
Soft coal, 1.2-2.6 m from surface	29,0	10,4	3,0
Soft coal, 4.3 m from surface	15,1	11,3	1,8
Soft fusainized coal, 7 m from surface	8,1	24,6	2,0
Soft fusainized coal, 10 m from surface	65,8	8,1	5,3
Lean coal, 23 m from surface	8,1	28,5	2,3
Lean coal, 24.4-34.4 m from surface	7,4	21,7	1,5
Lean coal, 37.0 m from surface	5,2	15,2	0,8
Humic acids of soft coal after extraction with metallic sodium in liquid ammonia	25,1	4,8	—

Note: Comma represents decimal point.

ording to this theory the carbon-carbon ds of the aromatic nucleus can be broken n under the action of hydrolyzing agents vided there is a  grouping.

rolytic breakdown of the carbon-carbon ds of this grouping is possible in all cases n under the influence of substituents, catal-, temperature, etc., the hydrogen of the roxyl group acquires a tendency towards disation and these bonds are sufficiently polar- l. Such substituents in the carbon atom are COOH, CO, and other groups which, as we w, appear at the initial stage of oxidation of l coals and, further, of humic acids. Naturxidation, which cannot cause the breakdown of the carbon-carbon bonds, therefore is a prerequisite for the subsequent hydrolytic breakdown of these bonds.

The hymatomelanic acid content in hard coals increases the more intensively they undergo the oxidation-hydrolytic destruction process of weathering. The same applies to vitrinized coals. In some cases, for example in fusainized soft coal, the hymatomelanic acid content is found to diminish as the intensity of weathering increases. We explain this effect as the result of further decomposition of the hymatomelanic acids to water-soluble polycyclic low molecular acids together with carbon oxides and water.

The action of metallic sodium in liquid ammonia

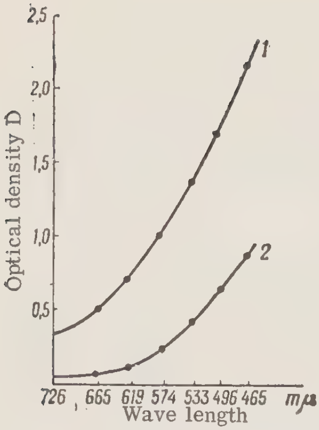


Fig. 2. - Optical density of alkaline solutions of humic acids from weathered hard coal (Baydayev shaft) and their alcohol-soluble fraction.

1 - initial humic acid; 2 - fraction soluble in ethyl alcohol after extraction with metallic sodium in liquid ammonia.

on humic acids also leads to the formation of an alcohol-soluble or dioxane-soluble fraction which, as Figure 2 shows, has a lower optical density than the insoluble residue. We regard this reaction as analogous to hydrolysis, since under the conditions in which it occurs the organometallic compound formed is decomposed by water.

The hymatomelanic acids extracted with dioxane consisted of a reddish-brown powder with a specific odor different from that of the acids extracted with alcohol. Their characteristics are shown in Table 4 and Figure 3. The values in the table describe hymatomelanic acids as methoxyl-containing phenolcarbon amorphous acids soluble in oxygen-containing organic solvents and containing nitrogen and sometimes sulfur. They differ from humic acids in having a lower molecular weight, lower optical density, higher methoxyl group content, and lower C/H ratio. These values indicate a relatively lower aromatic content in the molecule.

The hymatomelanic acids extracted from each test sample are a mixture of soluble acids of similar composition and molecular weight; the values given in Table 3 must therefore be regarded only as averages. There is a noticeable discrepancy between the molecular weight and the content in active acid groups, particularly in certain samples of weathered hard coals, where the mean molecular weight is less than the chemical equivalent.

Experiments performed at the Soil Institute of the USSR Academy of Sciences (2) have shown that the optical density values of solutions of humates from various soils vary within wide limits. Humic acids from podzolic soils show the least capacity to attenuate light: those from red earths and brown forest soils come next in this respect. Humic acids from chernozems possess a high optical density. The characteristics of humic acids from these soils as obtained from other indices (degree of dispersio oxidation, and hydration) show that the higher optical density to some extent reflects a gradu increase in the complexity of the molecules. This may be due also to a quantitative differen in the hymatomelanic acid content of the humic acids; a higher hymatomelanic acid content in the soil humic acids will undoubtedly influence the soil-formation processes.

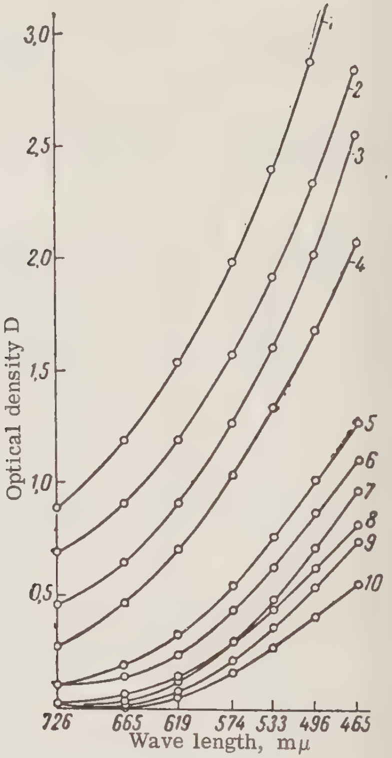
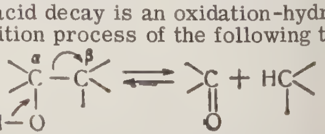


Fig. 3. - Optical density of alkaline solutions of humic and hymatomelanic acids from weathered hard coals at various stages of metamorphism, peat, and brown coal.

Humic acids: 1 - soft, fusainized; 2 - lean; 3 - soft; 4 - gas.
Hymatomelanic acids: 5 - from brown coal; 6 - from soft coal fusainized; 7 - from lean coal; 8 - from peat; 9 - from soft coal; 10 - from gas coal.

Hymatomelanic acid formation in the cours of humic acid decay is an oxidation-hydrolytic decomposition process of the following type:


$$\underset{H-O}{>\overset{\alpha}{C}}-\overset{\beta}{C}< \rightleftharpoons >\underset{O}{\overset{}{C}} + HC<$$

giving a more reduced as well as a more oxidized molecule. The oxidation processes a companying the hydrolysis, however, are not

Table 4

Characteristics of hymatomelanic and humic acids

Preparation	Elementary analysis, %					Molecular weight	Content of active acid groups by chemosorption method, meq/g			OCH_3, meq/g
	C	H	S	N	O (by difference)		Total	Carboxyls	Phenol hydroxyls (by difference)	
					Peat					
Iymatomelanic	62,75	6,57	0,97	2,42	27,29	292	5,79	2,61	3,18	1,91
Iumic	57,12	5,16	0,77	2,85	34,10	—	6,17	2,55	3,62	—
					Brown earth coal					
Iymatomelanic	59,44	5,60	2,64	0,44	32,32	332	7,91	3,00	4,91	1,38
Iumic	59,22	4,55	2,80	0,82	32,61	—	6,38	2,43	3,95	—
					Weathered coals					
					Gas					
Iymatomelanic	55,65	5,92	0,34	1,44	36,65	150	6,52	4,39	2,13	3,49
Iumic	66,80	4,54	0,14	2,02	26,50	—	5,05	2,16	2,89	—
					Soft					
Iymatomelanic	58,65	5,87	0,38	1,21	33,89	—	6,43	3,69	2,74	—
Iumic	67,19	4,16	0,40	1,97	26,28	—	4,98	2,34	2,64	—
					Lean					
Iymatomelanic	62,83	5,11	0,29	1,21	30,56	314	6,16	3,10	3,06	3,06
Iumic	66,70	3,46	0,35	1,78	27,71	—	5,29	3,08	2,21	—
					Soft after extraction of humic acids[a]					
Iymatomelanic	62,35	5,42	0,60	2,27	29,36	276	6,08	3,52	2,56	2,72
Iumic	67,13	4,17	0,59	3,34	24,77	—	5,50	2,29	3,21	—

[a] Extraction was performed with metallic sodium in liquid ammonia.

Note: Comma represents decimal point.

as to permit the separation of intermediate ucts which strictly fulfill the hydrolysis tion.

morphous, dioxane-soluble, and alcohol-ble acids—the so-called hymatomelanic s—are accordingly contained in soils and fossil fuels at the peat and brown coal es and also in weathered hard coals. They be formed as a result of synthesis from bac-l decay products of dead plant residues and through the destruction of the organic mat-n hard coals and humic acids. The com-tion and properties of hymatomelanic acids within certain limits, depending on the acter of the initial substances and the istry of their formation, but there is a y distinct borderline between them and the c acid group.

he foregoing research is important for our ledge of the chemical nature and genesis of humus. On the one hand, it shows that the rphous acids known as hymatomelanic are uced through synthesis in the process of the formation of more complex high molecular acids from dead plant residues. On the other hand, their formation can be by way of oxidation hydrolytic destruction of humic acids in the soil under the influence of oxygen and moisture.

Received June 19, 1959

BIBLIOGRAPHY

1. KONDRAT'YEV, YE. V. 1940. Study of humic acids. Zh. P. Kh., No. 12.

2. KONONOVA, M. M. 1951. Soil humus and current aims of soil humus study. Izd. Akad. Nauk SSSR.

3. KUKHARENKO, T. A. 1948. Study of hymatomelanic acids by the chemosorption method. Zh. P. Kh., No. 2.

4. KUKHARENKO, T. A., T. YE. VVEDENSKAYA. 1956. Separation of humic acids by metallic sodium in liquid ammonia.

Khimiya i tekhnol. topliva, No. 6.

5. KUKHARENKO, T. A. 1951-1954. Doctorate thesis (IGI Akad. Nauk SSSR Fund).

6. KUKHARENKO, T. A. and L. N. YEKATERININA. 1959. Determination of molecular weight of humic preparations cryoscopically in pyrocatechnol. Zh. P. Kh., vol. 32.

7. TYURIN, I. V. 1937. Soil organic matter. Selk'khozgiz.

8. SHEMYAKIN, M. M., and L. A. SHCHUKINA. 1957. Oxidation hydrolytic conversion of organic compounds. Uspekhi khimii, No. 5.

9. SSYSKOFF, K. I. 1936. Ueber die Adsorptio des Bariumhydroxyds durch die Huminsaeuren. Koll. Ztschr., 76, No. 2.

10. FUCHS, W. 1931. Die chemie der Kohle. Berlin.

FFECT OF WIND EROSION UPON SOME PHYSICAL AND HEMICAL PROPERTIES OF SOILS

. F. YAKUBOV, V. V. Dokuchayev Soil Institute, Academy of Sciences, USSR

Wind affects soils and influences soil-forma- on processes in a variety of ways. This was inted out long ago by Dokuchayev (5, 6), birtsev (10-13), Krasnov (7), Beletskiy (1), ychikhin (2), Shtal'-Shreder (15), Pul'man (9), l'yams (3), and many others. On the land rface the wind is continuously transferring il particles from one place to another. Even ough natural vegetation reduces the blowing d transporting of soil particles, it does not by y means prevent this, particularly under mi-arid and arid conditions.

The processes of soil erosion and the trans- rt of soil mass by the wind, which occur owly in nature, are appreciably accelerated by or land utilization; the wind then exerts a rong destructive influence on soil. As a re- lt of wind erosion fine soil particles are own away and irrevocably transported to some r distant point, while the coarse particles re- ain within the eroded areas or are deposited ar them. If this process is repeated many nes some soils lose all their fertility at the me time as they become coarser and are to a eat extent reduced to sand.

The influence of wind erosion on soils and on tering them has been studied little and our owledge of this question is very limited. evertheless, there is sufficient information ailable, both in Soviet (4, 8, 16, 17, etc.) and foreign literature to give us a general idea several aspects of the problem; but work in is direction is far from adequate and needs to much wider in scope and thoroughness, imarily in regard to soils which suffer most astic wind erosion and are already to some tent eroded. This is a necessity for agricul- re if we are to develop rational methods of otecting soils from wind erosion and, as is sential, improve eroded soils.

Research has shown that in many places soils the semi-arid and arid regions of the Great ains (Canada and the USA) have lost the most rtile arable layer during the last two or three cades owing to wind erosion, and that in some aces deeper horizons have been worn down ap- eciably by erosion (18, 27). As a result, the lative content of the soils in sand particles has increased appreciably (with a corresponding reduction in the silt and clay fractions), in wind-eroded soils as compared with non-eroded and virgin soils (18-22, 28 etc.). In the opinion of many investigators the increase of the sandy fraction in certain eroded soils is roughly proportional to the total quantity of silt and colloids blown away by the wind (19, 20). In soils which have suffered erosion, the water properties have changed, by comparison with non-eroded and virgin soils, owing to the removal of fine earths and organic matter, the moisture capacity and water retention capacity diminishing, particularly at tillage depth. It has been discovered also that eroded soils contain an appreciably smaller amount of coarse non-erodible water-stable aggregates. In certain soils, however, particularly clay loam, the reduced amount of these aggregates is partially offset by an increase in the amount of small water-stable aggregates smaller than 0.02 mm in diameter. These to some extent enhance the resistance of the soils to wind erosion, though not their resistance to water erosion (24).

Research performed at the Oklahoma agricultural experimental station (USA) has shown that eroded coarse-textured soils contain, on the average, 22.3% more sand and 53.1% less clay than virgin soil, the corresponding figures for medium-textured soils being 37.8% and 38.6%, and for fine-textured soils, 31.1% and 20.1%.

With repeated deflation soil textures have altered to an even greater extent. In soils which have suffered deflation four times, for example, the average sand content is 31.28% higher and the clay content 73% lower than in similar virgin soils.

This means that, as Table 1 and 2 show, coarse textured soils suffer most in regard to textural changes due to deflation, medium-textured soils come next, and fine-textured soils last (19, 20, 22, 25).

Tables 1 and 2 show that it is mainly the silt particles and to a lesser extent the clay particles which are deflated from clay loam and sandy loam soils in the process of wind erosion. The wind deposits of these soils are more sandy in texture while those of fine-textured soils differ little from the composition of the corresponding non-eroded soils.

Alterations in soil texture as a result of

---

ee Pochvovedeniye, 1959, Nos. 7 and 11.

Table 1

Texture of non-eroded cultivated soils and wind deposits, %. Saskatchewan (25).

Soil	Sand	Silt	Clay	Soil	Sand	Silt	Clay
Clay	10,20	19,86	60,50	Deposit	50,40	26,10	20,50
Deposit	10,70	19,90	60,50	Sandy-loam	70,00	11,70	13,60
Clay loam	34,10	35,66	24,22	Deposit	84,60	5,80	9,40

Note: Comma represents decimal point.

Table 2

Particle-size analysis of non-eroded and eroded soils and of wind deposits, %. Oklahoma (22).

Soil	Sand	Silt	Clay
Non-eroded	36,4	42,0	21,6
Eroded	58,2	15,0	26,8
Deposits	14,3	62,5	23,2

Note: Comma represents decimal point.

deflation cause corresponding changes in the chemical composition of the soils. Investigations in a number of states in the southern part of the great plains (Saskatchewan, Oklahoma and others) have shown that in the eroded soils the organic content as well as the content in nitrogen and other plant nutrients is lower than in non-eroded and virgin soils (19-22, 25, 26). It has been found that the organic content in eroded soils is on the average 24.5% less and the nitrogen content 28% less than in the corresponding virgin soils. The organic matter, nitrogen, and phosphorous content in coarse-textured deposits was found to be roughly half that of virgin soils. The difference in organic, nitrogen, and phosphorous content proved to be smaller in clay loam and clay soils than in coarse-textured soils (19, 22). Tables 3 and 4 show the result of chemical analysis of virgin, non-eroded, and eroded soils.

As the values in Tables 3 and 4 show, the reduction in organic matter, nitrogen, and phosphorus is most noticeable in coarse-textured deposits and least important in clay deposits, medium-textured soils falling between the two in this respect.

Research has shown that repeated and frequent soil deflation considerably increases losse of the most important elements of soil fertility. The organic matter content in soils which have been eroded once, for example, was 11.7% lower and the nitrogen content 10% lower than in simila virgin soils. In soils which have been subjected to erosion four times, the amount of organic matter was 52.2% less and the nitrogen amount 56.8%

Table 3

Chemical composition of virgin soils and eroded soils, %. Oklahoma (20).

Soil	Organic matter	Nitrogen	Difference[a]	
			Organic matter	Nitrogen
	Coarse-textured			
Virgin	1,77	0,073	—	—
Eroded	1,06	0,040	—40,1	—45,2
	Medium-textured			
Virgin	2,62	0,112	—	—
Eroded	2,11	0,087	—19,5	—22,3
	Fine-textured			
Virgin	2,90	0,131	—	—
Eroded	2,48	0,107	—14,5	—18,3

---

[a] Content in virgin soil taken as 100%.

Note: Comma represents decimal point.

Table 4

Chemical composition of non-eroded cultivated soils and wind deposits, %. Saskatchewan (25).

Soil	Hygroscopic water	Ignition losses	N	Phosphorus
			Total	
Clay	6,12	8,13	0,324	0,073
Deposit	6,04	7,82	0,308	0,076
Clay loam	2,80	6,22	0,238	0,069
Deposit	2,42	5,63	0,233[a]	0,055
Sandy-loam	1,64	3,78	0,171	0,041
Deposit	0,98	2,08	0,092	0,031

---

[a] The relatively high nitrogen content in the clay loam deposit is explained by the presence of not easily removable non-decayed plant residues.

Note: Comma represents decimal point.

s than in the corresponding virgin soils (20).

It was found that in the Alberta (Canada) cher- zems deflation of only 2.5 cm of the plow er caused a loss of 981 kg of nitrogen, 196 of phosphorus, and 15 metric tons of organic tter (30). Similar values are given for other irie regions in Canada, where soil deflation the depth mentioned has caused a loss of 785 of nitrogen, 175 kg of phosphorus, and 6,100 of potassium (23) per hectare. It has been ed that in the case of phosphorus alone the ount removed as a result of soil deflation been roughly as much as is taken up by eat to form 13 metric tons of grain.

The changes in soil texture as a result of d erosion are more serious than the loss of nt nutrients. To some extent these can be tored by appropriate selection of crops, and use of fertilizers and other methods, where- it is practically impossible or extremely dif- ult to restore the loss of valuable structuring moisture-retaining fine particles.

Apart from the damage already indicated, d erosion has a considerable effect on soil logy, too. Owing to the loss of organic mat- , nitrogen, and other elements from eroded ls, conditions for the activity of micro- anisms deteriorates appreciably. The com- ition and number of the microbe population ers and the activity of microbiological proc- es is reduced. Owing to the deflation of the se, more fertile top horizon and exposure of compacted less fertile lower horizons the elopment of beneficial microorganisms is iously restricted. Moreover, pathogenic robes sometimes develop in heavily eroded ls, making them "diseased" and exhausted).

Conclusions

1. Wind erosion, apart from the direct age it does to agriculture, does immense m to the soil itself. Soils become coarser and more sandy, this effect is increasingly severe in proportion to the soil texture: most severe on coarse-textured soil, less on medium-textured, and the least on fine-textured soil.

2. Wind erosion causes changes in the chemical composition of soils as well. Large amounts of organic matter, nitrogen, phosphorus, and other plant nutrients are removed from eroded soils. Alterations in the chemical composition of soil as a result of wind erosion are more or less severe, according to the texture of the soil, coarse-textured soils suffering most, the fine-textured soil the least, and the medium textured soil occupying an intermediate position.

3. Conditions for the activity of microorganisms deteriorate greatly in eroded soils as a result of their becoming coarser and losing organic matter as well as plant nutrients. The composition and population of beneficial microbes alters and "diseased" and exhausted soils appear.

4. It is of great practical importance to find out more about the influence of wind erosion on soil alteration. The problems entailed require thorough study, applied to specific soils in the light of the conditions under which they develop and are economically utilized.

Received February 1, 1960

BIBLIOGRAPHY

1. BELETSKIY, I. I. 1895. Soil science. Moscow.
2. BYCHIKHIN, A. O. 1892. The influence of winds on soil. Tr. Vol'no-ekonomich. o-va, No. 6.
3. VIL'YAMS, V. R. 1941. Soil science. Collected works, Vol. 1.
4. GAYEL', A. G. 1957. Wind erosion of coarse-

textured soils. In the collection: Bor'ba s eroziyey pochvy. Moscow.

5. DOKUCHAYEV, V. V. 1883. The Russian chernozems. St. Petersburg.

6. DOKUCHAYEV, V. V. 1886. Report to the Nizhegorod Zemstvo. Documents on land evaluation in the Nizhegorod Guberniya. vyp. XIV, St. Petersburg.

7. KRASNOV, A. N. 1895. Report on photogeographical investigations in the Kalmytsk steppe. Izv. Geolkoma, vol. XIV, No. 1.

8. LYSAK, G. 1958. Wind erosion of soils and erosion control measures in the Bashkirian ASSR. Zemledeliye, No. 2.

9. PUL'MAN, I. A. 1902. Erosion by atmospheric water and deflation by wind of the top chernozem layer from the surface of fields and methods of studying this question. 2nd Conference of Agricultural Experimentalists, St. Petersburg. 14-20 December, 1902, part I. St. Petersburg.

10. SIBIRTSEV, N. M. 1893. Preliminary report of expedition, June-November 1892, and general plan of experimental work. Special expedition of the Forestry Department for testing and evaluating ways and means in regard to forest and water economy in the Russian steppelands. St. Petersburg.

11. SIBIRTSEV, N. M. 1895. Principles of soil classification. Warsaw.

12. SIBIRTSEV, N. M. 1899. Soil science, parts II and III, St. Petersburg.

13. SIBIRTSEV, N. M. 1914. Soil science, St. Petersburg.

14. TUROTSEV, N. M. Dust storms in the Bashkirian ASSR and control measures. Alma-Ata, Vestn. s.-kh. nauk, No. 3.

15. SHTAL'-SHREDER, M. 1900. The action of wind on soil. Sel'sk. khoz. i lesovodstvo, No. 2.

16. YAKOBOV, T. F. 1956. The problem of protecting soils from wind erosion in the reclaimed and abandoned lands of Kazakhstan. Pochvovedeniye, No. 10.

17. YAKOBOV, T. F. 1957. The influence of wind erosion on the physical and chemical properties of the soil. Pochvovedeniye, No. 5.

18. CHEPIL, W. S., C. L. ENGLEHORN, and A. W. ZINGG. 1952. The effect of cultivation on erodibility of soils by wind. Proc. Soil Sci. Soc. Amer., 16(1).

19. DANIEL, H. A. 1936. The physical changes in soils of the southern High Plains due to cropping and wind erosion and the relation between the Sand + Silt: Clay ratio in these soils. J. Amer. Soc. Agr., 28(7).

20. DANIEL, H. A., and W. H. LANGHAM. 1936. The effect of wind erosion and cultivation on the total nitrogen and organic matter content of soils in Southern High Plains, J. Amer. Soc. Agr., 28(8).

21. ERDMAN, R. L. 1942. Effects of wind erosion on the composition and fertility of some Alberta soils. Sci. Agr., 22(9).

22. FLY, C. L. 1935. A preliminary report of a chemical and mechanical analysis of dust deposited by wind at Goodwell, Oklahoma. Panhandle Agr. Exp. Sta. Bull., No. 57.

23. HOPKINS, E. S., A. E. PALMER, and W. S. CHEPIL. 1946. Soil drifting control in the Prairie Provinces, D. C. Dep. Agr. Publ. 568, Farmer's Bull., No. 32. Ottawa—Canada.

24. MIDDLETON, H. E. 1930. Properties of soil which influence soil erosion. U. S. Dep. Agr. Techn. Bull., No. 178.

25. MOOS, H. C. 1935. Some field and laboratory studies of soil drifting in Saskatchewan. Sci. Agriculture, 15(10).

26. MURPHY, H. F. 1936. The deposition of dust in Central Oklahoma during the 1935 dust storms. Proc. Okla. Acad. Sci., No. 16.

27. RUE, S. A. 1955. Man and the wind. New York.

28. Soil moisture, wind erosion and fertility of some Canadian Prairie Soils. 1949. Soil Research Laboratory, Swift Current, Sask. D. C. Dep. Agr. Publ., No. 819.

29. WAKSMANN, S. 1937. Soil deterioration and soil conservation from the viewpoint of soil microbiology. J. Amer. Soc. Agr., 29(2).

30. WYATT, F. A. 1932. Soil types and management in relation to soil drifting. Univ. Alberta, Coll. Agric., Circ. 13. Alberta, Canada.

METHODS

HARACTERISTICS OF NORTHWEST CAUCASIAN BROWN OREST SOILS

. D. ZAYTSEV, Higher Forestry Course, Ministry of Agriculture, USSR

Despite the wide occurrence of brown forest
oils in the Caucasian mountain regions, these
oils have been insufficiently studied. Zonn (3)
oints out that the concept of "brown forest soils"
s insufficiently clear in Western Europe. An
dication of this can be found in Kundler's
aper (5). It is noteworthy that different in-
estigators have established the presence of
rown forest soils in places where physical-
eographical conditions are very different. Soils
rmed on coarse, shallow, and eroded deposits
-in other words, soils in which the soil-forma-
on process is undeveloped—also are frequently
lassed as brown forest soils. The brown for-
st soils classified by Prasolov (4) as a separ-
te genetic group require further study, pri-
arily regarding their chemical and physical
roperties under certain regional conditions.
he present communication includes certain sup-
lementary information on the peculiar charac-
eristics of brown forest soils formed under fir forests in the Caucasian mountains (upper reaches of the Laba River). Zonn (3) points out that the typical brown forest mountain soils developed here have been studied very little. Some preliminary information on them will be found in my earlier paper (1).

The soil profiles investigated were situated on carbonate-free deposits - shale (Profile 1), sandstone (Profile 3), and a transitional shale - sandstone, Profile 2.

The soil samples were subjected to the following analyses to obtain the characteristics of the soil-formation process layer by layer: 1) total chemical analysis with humus determination by the Knopp method; 2) determination of the colloidal substances - silica, aluminum, iron, and manganese (Tamm's method); 3) determination of exchangeable cations; 4) determination of actual acidity (pH); 5) particle size, micro-

Table 1

Results of total chemical analyses of brown forest soils

No.	Depth, cm	Hygroscopic moisture, %	As percentage of dry soil											
			Ignition losses	Mineral part of soil	Humus, total	Water of crystallization	SiO_2	Al_2O_3	Fe_2O_3	Mn_3O_4	CaO	MgO	Undetermined residue	Total
1	0—6	3,99	10,04	89,96	6,97	3,07	63,75	12,86	8,36	0,11	0,99	1,21	2,68	100,0
	6—15	2,65	3,99	96,01	1,39	2,60	64 34	16,12	10,67	0,14	0,85	1,66	2,23	100,0
	30—40	2,39	3,34	96,66	0,82	2,52	67,48	16,47	7,98	0,07	0,91	1,75	2,00	100,0
	115—120	2,53	3,06	96,94	0,41	2,65	61,67	20,92	7 75	0,04	0,89	2,20	3,47	100,0
2	0—10	2,80	6,65	93,35	4,16	2,49	69,66	12,37	5,86	0,02	0,75	0,94	3,75	100,0
	20—30	2,77	3,42	96,58	1,65	1,77	70,65	15,05	6,29	0,01	0,64	1,12	2,82	100,0
	85—95	2,16	2,26	97,74	0,46	1,80	69,91	15,57	7,73	0,06	0,65	1,72	2,10	100,0
3	0—8	3,19	13,21	86,79	10,00	3,21	76,47	5,59	1,70	0,01	0,51	0,46	2.05	100,0
	8—14	1,73	5,55	94,45	3,30	2,25	83,04	6,85	1,98	0,01	0,41	0,53	1,63	100,0
	40—50	1,80	3,05	96,95	0,40	2,65	79,53	10,60	3,62	0,05	0,48	1,05	1,62	100,0

ote: Comma represents decimal point.

Table 2

Acidity and composition of exchangeable cations in brown forest soils

Profile No.	Depth, cm	pH		Exchangeable cations per 100 g of dry soil						Percentage composition of exchangeable cations			Adsorption capacity, meq/100 g of dry soil	Degree of unsaturation
				grams			meq							
		Water	Salt	H	Ca	Mg	H	Ca	Mg	H	Ca	Mg		
1	0—6	5,9	5,3	0,0001	0,344	0,059	0,1	17,2	4,9	0,4	77,5	22,1	22,2	0,4
	6—15	5,8	4,8	0,0003	0,078	0,044	0,3	3,9	3,7	3,8	49,4	46,8	7,9	3,8
	30—40	6,2	5,2	0	0,082	0,044	0	4,1	3,7	0	52,6	47,4	7,8	0
	115—120	3,2	5,4	0	0,164	0,066	0	8,2	5,5	0	59,9	40,1	13,7	0
2	0—10	5,8	4,8	0,0011	0,108	0,037	1,1	5,4	3,1	11,5	56,2	32,3	9,6	11,5
	20—30	6,0	5,0	0,0007	0,090	0,049	0,7	4,5	4,1	7,5	48,4	44.1	9,3	7,5
	85—95	6,0	5,2	0	0,030	0,030	0	1,5	2,5	0	37,5	62,5	4,0	0
3	0—8	5,0	3,7	0,0017	0,072	0,019	1,7	3,6	1,6	24,6	52,2	23,2	6,9	24,6
	8—14	5,5	4,6	0,0006	0,028	0,020	0,6	1,4	1,7	16,2	37,8	46,0	3,7	16,2
	40—50	5,7	4,8	0,0003	0,020	0,023	0,3	1,0	1,9	9,4	31,2	59,4	3,2	9,4

Note: Comma represents decimal point.

aggregate, aggregate, and structure analyses; 6) determination of the bulk and particle density, porosity, maximum hygroscopicity, and Atterberg constant.

The samples from the topmost layer (0-6, 0-10, 0-8 cm) can be classified as belonging to the humus-accumulative horizon (A), those from the middle layer (6-15, 30-40, 20-30, 8-14 cm) to the transitional horizon (B), since they lack external signs of podzol-formation processes, and those from the deepest layers (115-120, 85-95, 40-50 cm) to soil-forming deposits (C) which have been altered little by soil-forming process

The total chemical analyses (Table 1) clearly indicate loss of cations from the top horizons of the soils studied. By way of contrast there is

Table 1

(continuation)

As percentage of mineral part of soil								Coefficients				
									Molecular ratios			
SiO_2	Al_2O_3	Fe_2O_3	Mn_3O_4	CaO	MgO	Undetermined residue	Total	Q (Rode)	$\frac{SiO_2}{Al_2O_3}$	$\frac{SiO_2}{Fe_2O_3}$	$\frac{SiO_2}{R_2O_3}$	Degree of magnesium silicate removed
70,87	14,30	9,29	0,12	1,11	1,35	2,96	100,0	—28,1	8,4	20,3	5,9	42,6
67,01	16,79	11,11	0,14	0,89	1,73	2.33	100,0	—13,7	6,8	15,2	4,8	23,6
69,81	17,04	8,26	0,07	0,94	1,81	2,07	100,0	—24,4	7,0	22,1	5,3	19,9
63,62	21,58	7,99	0,04	0,92	2,27	3,58	100,0	0	5,0	21,1	4,0	0
74,62	13,25	6,28	0,02	0,80	1,01	4,02	100,0	—14,6	9,6	31,6	7,3	45,3
73,15	15,58	6,52	0,01	0,66	1,16	2,92	100,0	—7,8	8,0	29,8	6,3	34,7
71,52	15,94	7,91	0,06	0,65	1,76	2,15	100,0	0	7,6	23,6	5,8	0
88,11	6,44	1,96	0,01	0,59	0,54	2,36	100,0	—37,7	23,2	121,6	19,4	51,9
87,92	7,25	2,10	0,01	0,43	0,56	1,73	100,0	—37,3	20,6	110,5	17,4	49,0
82,03	10,94	3,73	0,05	0,50	1,08	1,67	100,0	0	12,7	58,1	10,4	0

Note: Comma represents decimal point.

an accumulation of silica in these horizons. The heaviest losses, however, as evident in Table 1, are in aluminum and magnesium. This is well illustrated by the values of the weathering and leaching accumulation coefficients. Iron removal occurs only in two profiles (2 and 3), the iron content in the top horizons of profile 1 showing an increase as compared with the lower horizons. This may be due to the heterogeneous character of the soil-forming deposits since it is not typical of the other two profiles, but the influence of the soil-forming deposit itself (shale) may also contribute. Zonn (3) points out the possibility of organic iron accumulation in the top horizons of brown forest soils.

The total chemical analyses also reveal an accumulation of calcium in the top horizons. The deeper horizons, with a low humus content, show a decrease in the total calcium content as compared with soil-forming deposits. If, however, we take into account silicate calcium, we find that the spread of calcium content values is no longer of the same order. This was done by subtracting the amount of exchangeable calcium from the total. It was found that the horizons with a high humus content (profiles 1 and 3) characteristically revealed a decrease in the value for silicate calcium content as compared with the soil-forming deposit—a result of calcium accumulation by the humus present in those horizons.

The SiO_2: Al_2O_3 and SiO_2: R_2O_3 ratios, Q (Rode) and the degree of silicate magnesium removal provide a further good illustration of the loss of material from the top horizons of brown forest soils. On the other hand, these values vary greatly from one profile to another in certain cases as a result of differences in the nature of the soil-forming deposits.

All the soils studied are characterized by a considerable humus content in the top horizons (4%-10%). Humus accumulation here is due to its reinforcement with calcium.

The presence of an acid reaction and of exchangeable hydrogen among the exchangeable cations (Table 2) is noteworthy. The acidity of soils studied, increases from profile 1 to profile 3, revealing a connection with the character of the soil-forming deposit. This phenomenon appears more clearly in relation to the salt pH and the exchangeable hydrogen content and is expressed in the degree of unsaturation. The soil acidity values, however, are appreciable only in the case of profile 3. The exchangeable cation content, and also the adsorption capacity are relatively low and are connected with the humus content and the character of the soil-forming deposit. Examining the values for exchangeable cation content and adsorption capacity by horizons in profile 1, we find them decreasing in the middle part of the profile, a characteristic feature of sod-podzolic soils. The absence of this feature in profiles 2 and 3 can be explained by the low adsorption capacity of their parent material, a phenomenon also observed in podzolic soils where the soil-forming deposits are poor in exchangeable cations.

Table 3 shows the values for various substances in the colloid state (SiO_2, Al_2O_3, Fe_2O_3 and Mn_3O_4) as determined by Tamm's method.

Colloidal substances in brown forest soils

Profile Number	Depth, cm	per 100 g of mineral part of soil								Ratios			Percentage composition		
		In grams					In millimoles								
		SiO_2	Al_2O_3	Fe_2O_3	Mn_3O_4		SiO_2	Al_2O_3	Fe_2O_3	$\frac{Al_2O_3}{SiO_2}$	$\frac{Fe_2O_3}{SiO_2}$	$\frac{Fe_2O_3}{Al_2O_3}$	SiO_2	Al_2O_3	Fe_2O_3
1	0—6	0,052	0,037	0,295	0	0,434	0,866	0,853	1,846	0,99	2,13	2,17	24,3	23,9	51,8
	6—15	0,043	0,067	0,307	0,054	0,471	0,716	0,657	1,922	0,92	2,68	2,93	21,7	19,9	58,4
	30—40	0,027	0,048	0,204	0,023	0,302	0,450	0,471	1,277	1,04	2,84	2,72	20,5	21,4	58,1
	115—120	0,016	0,034	0,101	0,037	0,188	0,266	0,333	0,632	1,25	2,38	1,90	21,6	27,1	51,3
2	0—10	0,027	0,152	0,370	0,022	0,571	0,450	1,490	2,317	3,31	5,13	1,55	10,6	35,0	54,4
	20—30	0,037	0,154	0,271	0,010	0,472	0,616	1,510	1,698	2,45	2,75	1,11	16,2	39,7	44,1
	85—95	0,047	0,097	0,232	0,038	0,414	0,783	0,951	1,453	1,22	1,87	1,54	24,6	29,8	45,6
3	0—8	0,065	0,006	0,190	0	0,261	1,082	0,059	1,190	0,05	1,10	20,17	46,4	2,6	51,0
	8—14	0,021	0,033	0,274	0	0,328	0,350	0,324	1,716	0,93	4,90	5,30	14,6	13,6	71,8
	40—50	0,047	0,021	0,137	0	0,205	0,783	0,206	0,858	0,26	1,10	4,17	42,4	11,2	46,4

Note: Comma represents decimal point.

Table 4

Mineral content of brown forest soils

Profile No	Depth, cm	SiO_2			Al_2O_3			Fe_2O_3			Mn_3O_4			CaO			MgO			Total			
		Total	Silicate	Colloidal	Total	Silicate	Colloidal	Total	Silicate	Colloidal	Total	Silicate	Colloidal	Total	Silicate	Exchangeable	Total	Silicate	Exchangeable	Total	Silicate	Colloidal	Exchangeable
1	0—6	70,87[a]	70,82	0,05	14,30	14,21	0,09	9,29	9,00	0,29	0,12	0,12	0	1,11	0,58	0,53	1,35	1,24	0,11	97,04	95,97	0,43	0,64
		100,0	99,93	0,07	100,0	99,37	0,63	100,0	96,88	3,12	100,0	100,0	0	100,0	52,25	47,75	100,0	91,35	8,15	100,0	98,90	0,44	0,66
	6—15	67,01	66,97	0,04	16,79	16,72	0,07	11,11	10,80	0,31	0,14	0,09	0,05	0,89	0,78	0,11	1,73	1,65	0,08	97,67	97,01	0,47	0,19
		100,0	99,94	0,06	100,0	99,58	0,42	100,0	97,13	2,87	100,0	64,29	35,71	100,0	87,64	12,36	100,0	95,38	4,62	100,0	99,32	0,48	0,20
	30—40	69,81	69,78	0,03	17,04	16,99	0,05	8,26	8,06	0,20	0,07	0,05	0,02	0,94	0,82	0,12	1,81	1,73	0,08	97,93	97,43	0,30	0,20
		100,0	99,96	0,04	100,0	99,71	0,29	100,0	97,58	2,42	100,0	71,43	28,57	100,0	87,23	12,77	100,0	95,58	4,42	100,0	99,49	0,31	0,20
	115—120	63,62	63.60	0,02	21,58	21,55	0,03	7,99	7,89	0,10	0,04	0	0,04	0,92	0.68	0,24	2,27	2,16	0,11	96,42	95,88	0,19	0.35
		100,0	99,97	0,03	100,0	99,86	0,14	100,0	98,75	1,25	100,0	0	100,0	100,0	73,91	26,09	100,0	95,15	4,85	100,0	99,44	0,20	0,36
2	0—10	74,62	74,59	0,03	13,25	13,10	0,15	6,28	5,91	0,37	0,02	0	0,02	0,80	0.56	0,24	1,01	0,93	0,08	95,98	95,09	0,57	0,32
		100,0	99,96	0,04	100,0	98,87	1,13	100,0	94,11	5,89	100,0	0	100,0	100,0	70,00	30,00	100,0	92,18	7,92	100,0	99,07	0,59	0,33
	20—30	73,15	73,11	0,04	15,58	15,43	0,15	6,52	6,25	0,27	0,01	0	0,01	0,66	0,55	0,11	1,16	1,11	0,05	97.08	96,45	0,47	0,16
		109,0	99,95	0,05	100,0	99,04	0,96	100,0	95,86	4,14	100,0	0	100,0	100,0	83,34	16,66	100,0	95,69	4,31	100,0	99,35	0,48	0,17
	85—95	71,52	71,47	0.05	15,94	15,84	0,10	7,91	7,68	0,23	0,06	0,02	0,04	0,66	0,52	0,14	1,76	1,70	0,06	97,85	97,23	0,42	0,20
		100,0	99,93	0,07	100,0	99,37	0,63	100,0	97,09	2,91	100,0	33,34	66.66	100,0	78,79	21,21	100,0	96,59	3,41	100,0	99,36	0,43	0,20
3	0—8	87,99	87,92	0,07	6,44	6,43	0,01	1,96	1,77	0,19	0,01	0,01	0	0,59	0,48	0,11	0,54	0,50	0,04	97,53	97,11	0,27	0,15
		100,0	99,92	0,08	100,0	99,84	0,16	100,0	90,31	9,69	100,0	100,0	0	100,0	81,19	18,81	100,0	94,59	7,41	100,0	99,57	0,28	0,15
	8—14	87,92	87,90	0,02	7,25	7,22	0,03	2,10	1,83	0,27	0,01	0,01	0	0,43	0,39	0,04	0,56	0,53	0,03	98,27	97,88	0,32	0,07
		100,0	99,98	0,02	100,0	99,59	0,41	100,0	87,14	12,86	100,0	100,0	0	100,0	90,70	9,30	100,0	94,64	5,36	100,0	99,60	0,33	0,07
	40—50	82,03	81,98	0,05	10.94	10,92	0,02	3.73	3,59	0,14	0,05	0,05	0	0,50	0,47	0,03	1,08	1,04	0,04	98,33	98,05	0,21	0,07
		100,0	99,94	0,06	100,0	99,81	0,19	100,0	96,25	3,75	100,0	100,0	0	100,0	94,00	6,00	100,0	96,30	3,70	100,0	99,72	0,21	0,07

---

[a] Numerator — content in grams per 100 g of mineral part of soil; denominator — percentage of total.

Note: Comma represents decimal point.

Table 5

Structural and aggregate analysis of brown forest soils

Profile Number	Depth, cm	Structural fraction as percentage of total						Aggregate fraction as % of total			
		>10 mm	10—5 mm	5—3 mm	3—2 mm	2—1 mm	<1 mm	2—1 mm	1—0,5 mm	0,5—0,25 mm	<0,25 mm
1	0—6	5,86	17,32	18,47	28,49	22,69	7,17	63,54	15,67	7,33	13,46
	6—15	69,96	12,63	5,81	3,62	4,06	3,92	78,44	6,91	2,23	12,42
2	0—10	28,73	27,13	19,24	9,73	7,53	7,64	92,46	0,60	1,16	5,78
	20—30	13,25	22,90	17,90	10,51	16,14	19,30	77,68	7,27	2,81	12,24
3	0—8	28,57	18,34	11,50	8,68	16,42	16,49	68,97	10,40	5,34	1 ,29
	8—14	73,34	14,81	3,64	1,75	2,73	3,73	38,14	12,20	8,79	40,57

Note: Comma represents decimal point.

Table 6

Microaggregate and particle-size analyses of brown forest soils

Profile Number	Depth, cm	Microaggregate fraction as percentage of total				Particle size fraction as percentage of total					Dispersion coefficient (Kachinskiy)
		>0,01 mm	0,01—0,005 mm	0,005—0,001 mm	<0,001 mm	>0,01 mm	0,01—0,005 mm	0,005—0,001 mm	<0,001 mm	Passed into solution	
1	0—6	85,9	11,1	1,5	1,6	45,7	13,0	17,9	23,4	1,60	7
	6—15	79,8	13,7	2,8	3,7	42,4	16,2	24,6	16,8	1,12	22
	30—40	69,1	22,0	4,5	4,4	50,1	12,3	23,0	14,6	1,25	30
	115—120	78,6	13,1	3,8	4,5	66,3	8,4	14,9	10,4	0,98	43
2	0—10	89,2	7,1	1,1	2,6	64,0	10,2	15,5	10,3	1,23	25
	20—30	88,5	7,8	1,0	2,7	61,7	3,6	23,2	11,5	0,85	23
	85—95	80,7	13,0	3,6	2,7	62,0	8,9	13,0	16,1	0,72	17
3	0—8	94,9	3,1	0,7	1,3	54,2	11,4	18,4	16,0	0,63	8
	40—50	84,7	11,4	0,5	3,8	68,3	7,8	13,9	10,2	0,38	37

Note: Comma represents decimal point.

values indicate that comparatively small ntities of these substances are extractable oxalate extract. The colloidal iron content elatively high. A considerable reduction in colloidal matter content (total, and regard-each substance separately) is observed in deepest horizons. Profile 3 is an exception; e the colloidal aluminum content is lowest in topmost horizon. A certain tendency to-ds colloidal aluminum and iron accumulation ne middle part of the profile can be noted file 1 and particularly profile 3). The col-al iron to colloidal aluminum ratio (F_2O_3: O_3) varies from 1 to 5 except in the 8 cm r of profile 3, where it is 21. This high re may be connected with peculiarities of soil-forming deposit (sandstone). In gener-ne Fe_2O_3:Al_2O_3 ratio shows some connection the character of the soil-forming deposit.

Table 4 gives the consolidated results of de-nining various forms of mineral substances along the profiles of the soils studied. The silicate part was determined as the difference between the total content in mineral substances and their colloidal and exchangeable parts.

Turning now to the characteristics of the physical properties of the soils studied, we note first the presence of a nutty-granular structure in their top humus-accumulative horizons. As the aggregate analyses (Tyurin method) showed, the structure of these soils is highly water stable (Table 5). The results of the microaggregate and particle-size analyses are shown in Table 6. The microaggregate analysis was performed after preparing the soils by pulverizing with a rubber pestle and sieving through a 1 mm mesh; the sample was then agitated in cylinders with distilled water and the fraction was determined by Robinson's method. In the particle-size analysis the organic matter was oxidized with hydrogen peroxide, the soil dispersed, and the exchangeable cations removed with 0.05 n HCl,

Table 7

Influence of dispersing agents on colloidal clay amount, and dispersion coefficient of soils studied

Profile Number	Depth, cm	Distilled water	Hydrogen peroxide	Oxalate solution	0,5 n HCl	Hydrogen peroxide	Oxalate solution	0,05 n HCl
		Particles <0.001 mm in diam. in %				K - dispersion coefficient		
1	0—6	1,6	18,2	3,8	2,6	9	42	80
2	0—10	2,6	15,4	3,8	2,5	17	68	104
3	0—8	1,3	11,4	1,2	3,8	11	103	34

Note: Comma represents decimal point.

Table 8

Physical properties of brown forest soils

Profile Number	Depth, cm	Particle density	Bulk density, g/cm³	Porosity, %	Maximum hygroscopicity, %	Atterberg limits		
						Upper plastic limit	Lower plastic limit	Plasticity number
1	0—6	2,58	1,03	60,02	8,71	63,35	49,72	13,63
	6—15	2,61	1,78	33,35	6,21	36,79	26,14	10,65
2	0—10	2,62	1,15	56,11	6,61	41,07	35,66	5,41
	20—30	2,65	1,25	52,84	5,87	38,87	25,39	13,48
3	0—8	2,41	0,96	60,13	8,32	Non-plastic		
	8—14	2,66	1,79	32,71	5,78	31,66	24,89	6,77

Note: Comma represents decimal point.

which was then removed and the suspension made alkaline with ammonia.

The results obtained show that the soils investigated possess a water-stable microstructure. The dispersion method used increases the colloidal clay content (particles <0.001 mm in diameter) many times, not only in the top (humus) horizons but also lower down. The dispersion coefficients (Kachinskiy method) shown in Table 7 well illustrate this. From the particle-size analysis data it can be seen also that these soils contain a considerable amount of physical clay (particles <0.01 mm in diameter)—between 32% and 58%—and can be classified as medium and fine clay loams.

A specific investigation was made to find which substances in the soils under study were the glue or cemented microaggregates. Soil samples triturated and sieved through a 1 mm mesh were treated with hydrogen peroxide, oxalate solution B, and 0.05 n HCl. The hydrogen peroxide first removed the organic matter, the oxalate solution then removed the sesquioxides, and the washing with 0.05 n HCl finally removed the exchangeable cations (calcium). We must assume that the humus, sesquioxides, and exchangeable calcium were the principal structuring substances.

Without bringing in original material already published by us (2), we shall characterize the action of the dispersing agents used by the values for the colloidal clay fraction and the dispersion coefficient (Table 7) in the top humus-accumulative soil horizons. The values given in Table 7 show fairly clearly that in these horizons organic matter is the main structural cement.

In addition to data on the structure and particle-size analysis of brown forest soils in the upper reaches of the Laba River, we also obtained information about their physical properties (Table 8).

Conclusions

1. Investigation of the chemical and physical properties of 3 brown forest soil profiles situate in the upper reaches of the Laba River (northwestern Caucasus) revealed peculiarities in the process of their formation. These peculiarities, indicating a weathering and leaching process, are: a) the accumulation of silica in the top soil horizons accompanied by spontaneous loss of cations, primarily aluminum and magnesium and secondarily iron; b) the presence of an acid reaction and of exchangeable hydrogen in the top horizons; c) the presence of a tendency towards accumulation of iron in the colloidal form in the middle part of the profile (profiles 1 and 3); and d) an increase in the content of total and

:hangeable calcium in the humus-accumula-
e as compared with the deeper horizons.

All these chemical features are also peculiar
sod-podzolic soils.

2. The brown forest soils studied also pos-
s certain properties distinguishing them
m podzolic soils, namely: a) the absence of
rphologically visible signs of podzolization;
the presence of a pronounced and relatively
ck humus-accumulative horizon with a con-
erable humus content; and c) the presence of
utty-granular structure in the humus-
umulative horizons. In these features the
wn forest soils resemble grey forest soils.

3. Study of the microaggregate composition
the soils concerned and an experiment in dis-
rsing the microaggregates of the humus ac-
nulative horizons by means of hydrogen per-
de, oxalate solution; and washing with 0.05
ICl, showed that the main structuring cement
these horizons is humus.

Received March 4, 1960

BIBLIOGRAPHY

1. ZAYTSEV, B.D. 1943. A contribution on the Caucasian brown forest soils. Pochvovedeniye, No. 1-2.

2. ZAYTSEV, B.D. 1949. Organic matter in the profile of forest soil. Forestry research. VNIILKh, No. 26, Moscow—Leningrad.

3. ZONN, S.W. 1960. Mountain forest soils of the northwest Caucasus. Izd-vo Akad. Nauk SSSR.

4. PRASOLOV, L.I. 1929. Crimean and Caucasian brown earths. Priroda, No. 5.

5. KUNDLER, P. 1957. Zur Charakterisierung und Systematik der Brauen Waldböden. J. Pilanzenernähr, Düng. Bodenkunde, No. 2-3.

MINERALOGICAL COMPOSITION OF THE CLAY FRACTIONS OF CRIMEAN CHERNOZEMS[1]

L. P. ABRUKOVA, V. V. Dokuchayev Soil Institute, Academy of Sciences, USSR (Received April 11, 1960)

The great importance of the colloid mineral composition of soils for their fertility has been noted by Gedroyts, Antipov-Karatayev, Gorbunov, and others (1, 5, 9-13, 24).

In 1932 Gedroyts (5) wrote, in connection with the possibility of studying the mineralogical composition of soils: "At present we are still in no position to give even a partially satisfactory answer to the question of just which compounds make up the solid part of a given soil. This impossibility of knowing even more or less accurately the composition of the original compounds in a given soil, the extremely tentative nature of our knowledge in this respect, makes it impossible to approach the study of soil dynamics directly and means that our inferences and assumptions lack sufficient grounds and are speculative."

Today Gorbunov and his co-workers are developing Gedroyt's line of thought in regard to studying the adsorption complex in soil, particularly its mineralogical composition. Gorbunov and Bekarevich (14), for example, have been able to draw valuable agricultural practices about the soil crust as a result of their work on the finely dispersed part of the Azerbaydzhan soils.

Our purpose in investigating the mineralogical composition of the colloidal clay fraction in the Crimean chernozems was to further the study of their properties, mainly the adsorption complex, which is the main index of fertility potential. The Crimean chernozems — their general morphological properties and their physical and chemical composition — have been studied in fair detail by Klepinin, Gusev, et al., Dzens-Litovskaya, Sobolev, Popova (2, 18, 19, 21, 22, 25) and others; but regarding the adsorption complex or active part of the soil, descriptive work, particularly on the mineralogical composition, has been rather weak until now. Many secondary minerals (montmorillonite, beidellite and others) give rise to undesirable effects because of their capacity for swelling, their stickiness, and the modification they cause to adsorption and other properties. Heavy swelling during wet periods of the year followed by shrinking, with the formation of deep cracks, in the dry season adversely affects the growth of agricultural crops by injuring the root system and so forth.

The chernozems we chose for investigation ar typical of the Crimean peninsula — they are poor in humus and have a fine texture and a high carbonate content. Table 1 summarizes their characteristics.

The colloidal fraction was separated by the method used in the Soil Institute of the USSR Academy of Sciences (10). Modern methods of investigation (electron microscopy, X-ray, DTA) were used, as well as physicochemical analysis.

Thermal analysis revealed the minerals predominant in the colloidal clay fraction. Figure 1 shows the relevant thermograms produced by a Kurnakov automatic thermograph with a platinum-platinrhodium thermocouple.[2] Calcined aluminum oxide was used as the standard of comparison. Heating was at the rate of 10-12°C per minute. Weight samples of 3 g were taken for the macro-investigations and of 0.15 g for the micro-investigations. Organic matter was removed from the samples by a single treatment with 30% hydrogen peroxide, after which the samples were kept for 5 days in a desiccator over a saturated solution of calcium nitrate at 50% relative air humidity. The samples were heated from 20 to 1,040°C. Thermograms obtained under identical conditions for the standard samples of clay minerals were used in interpreting the soil thermograms (16).

Each curve in Figure 1 shows characteristic and very pronounced peaks and dips: two endothermal (t = 90-105°C; 510-550°C) and one exothermal (t = 900-925°C); these are typical of the beidellite-type minerals in the montmorillonite group.

Only those clay minerals which predominate in the soil can be detected by thermal analysis;

---

[1] The analytical part of this work was done in 1953-1956 at the Crimean branch, Academy of Sciences, USSR. The material was treated in the Dokuchayev Soil Institute, Director — Prof. N. I. Gorbunov.

[2] The thermal analysis was performed by B. M. Tunil in the mineralogy laboratory of the Dokuchayev Soil Institute; Ye. A. Shurygina interpreted the thermograms.

Table 1

Characteristics of samples investigated

Profile No.	Soil and location of profile	Depth, (cm)	Humus, (%)	Carbonate content, (%)		% of particles <0.001 mm in diamet.
				$CaCO_3$	$MgCO_3$	
1 LA	Southern chernozem, poor in humus, fine clay loam, on yellow brown Pleiocene clay. Mezhgornoye, Saki rayon.	0—10 30—40 90—100	3,39 2,64 0,68	17,02 24,85 36,17	0,91 1,75 1,08	50,45 56,72 53,16
4[a] NS	Southern chernozem, poor in humus, coarse clay, on yellow brown loess-like clay. Novosel'ye, Krasnogvardeisk rayon.	0—10 45—55 140—150	3,02 1,82 0,28	2,65 14,31 16,71	0,99 1,04 1,10	70,04 52,19 75,54
1 LA	Southern chernozem, poor in humus, coarse clay, on Sarmatic clay. Saraymin, Primorskiy rayon, Kerchen peninsula.	0—10 50—60 190—195	3,62 2,33 0,41	4,21 16,2 6,9	0,81 1,55 1,39	71,18 70,07 66,14

---

[a] The author thanks N. F. Sevost'yanov for the opportunity of using samples from profile 24 NS in this work.

Note: Comma represents decimal point.

dmixture of other minerals can be detected ther methods.

The X-ray examination was made with an iron-ssion electron tube at a voltage of 40 kW a current of 7 mA, the samples being ex-ed for 22 hours. The X-ray photographs e interpreted by comparing them with the dard X-ray patterns for the particular erals and their mixtures with amorphous stances.

Despite the variety of the parent materials ss-like clay loams in profile 24 and Sarma- clay in profile 11), the mineralogical com- tion of the southern chernozems (Table 2) ved to be qualitatively uniform. The pre- inant mineral is beidellite but there is an reciable quartz and hydromica content. In 190-195 cm layer (profile 11 LA) the unt of hydromica is about 10%.

n interpreting the X-ray photographs and mograms the total chemical analysis of colloidal clay fraction, together with its sical-chemical characteristics (adsorp- capacity, hygroscopicity, swelling, etc.) e of great help. Table 3 shows the total mical analysis data for the colloidal clay tion of the southern chernozems. The :R_2O_3 ratio varies from 2.5 to 3. 20. This pical of beidellite minerals of the mont- illonite group.

hurygina (26) studied the total chemical position of beidellite and ferri-beidellite; $SiO_2:R_2O_5$ ratio for the former was 2. 7 and he latter, 2. 31. The total chemical analysis (Table 3) thus corroborate the thermographic and X-ray findings in regard to the colloidal clay fraction of the Crimean chernozems.

We now examine the distribution of silicate forms of calcium and magnesium in the colloidal clay fraction. The carbonate content in the chernozems under study reaches high values — from 5%-8% to 30%-35% (Table 1), but there is very little silicate calcium in the soil — 0.1%-1.3%. In all the samples analyzed magnesium predominated over silicate calcium. The soil contains calcium in very large quantities, in the form of $CaCO_3$, but there was very little magnesium carbonate in the samples.

Rode (23) points out that in the soils "the silicate CaO content diminishes with partial size, whereas the silicate MgO content rises." He established by specially set up experiments (treatment with 1% HCl or NaOH solution) that CaO possesses far greater mobility than MgO; 84%-100% of the initial CaO content passed into a solution, against only 16%-49% of the MgO. On the basis of these experiments, Rode suggests that the colloids separated contain CaO exclusively in adsorbed form and that "conversely, although MgO and other cations also possess marked mobility, by no means do all of them pass into solution, and we can therefore assume that they have a more stable form of bond."

The high magnesium oxide content in the colloidal clay fraction of the Crimean chernozems fully bears out Rode's hypothesis of a more stable form of magnesium bond. Magnesium apparently enters into the composition of the crystal lattice of minerals in the soil, whereas calcium is found mainly in adsorbed form.

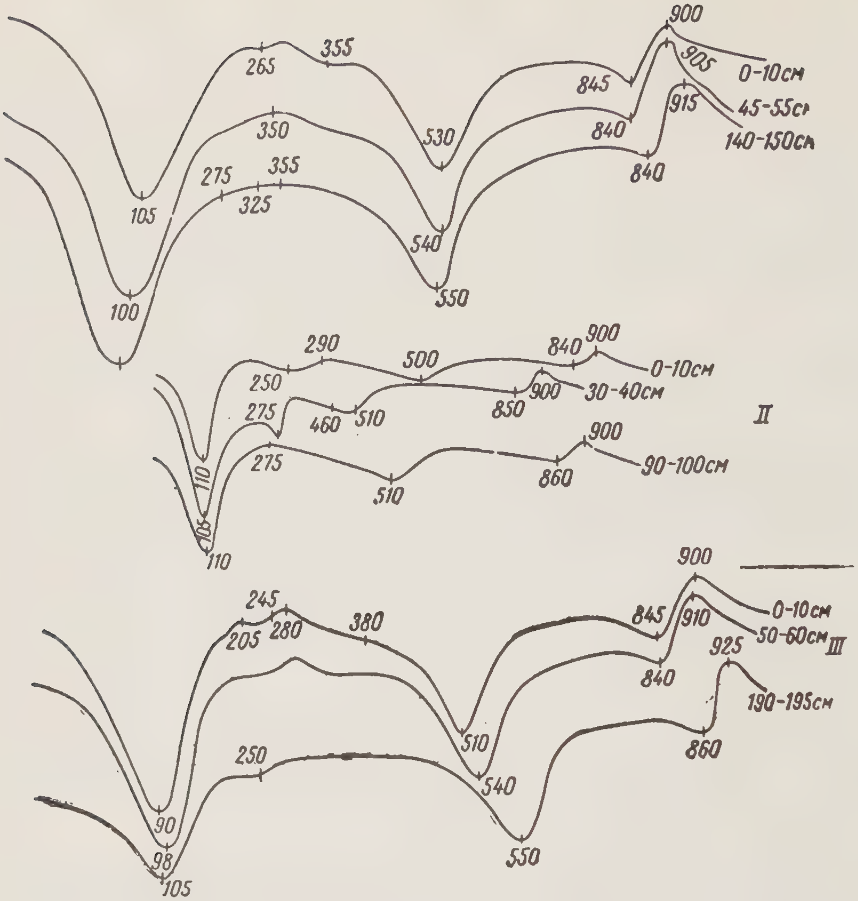


Fig. 1. - Thermograms for colloidal clay.
I - profile 24 NS; II - profile 1 LA; III - profile 11 LA.

Table 2

X-ray of colloidal clay fraction from Crimean chernozems[a]

Line No.	Profile 11 Depth 0-10 cm		Profile 11 Depth 190-195 cm		Profile 24 Depth 140-150 cm		Line No.	Profile 11 Depth 0-10 cm		Profile 11 Depth 190-195 cm		Profile 24 Depth 140-150 cm	
	I	dA	I	dA	I	dA		I	dA	I	dA	d	dA
1	9	4,45	8	4,45	9	4,45	9	7	1,78	4	1,82	7	1,78—
2	1	3,63	1	3,63	1	3,63			1,48—				1,68
3	9	3,34	9	3,34	2	3,47	10	9	1,50	1	1,78	9	1,48—
4	3	2,81	3	2,81	9	3,32							1,50
5	9	2,55	9	2,55	3	2,81	11	7	1,3	8	1,68	7	1,38
6	1	2,13	1	2,26	9	2,55	12	8	1,25	1	1,53	6	1,29
7	4	2,09	2	2,12	3	2,09	13	—	—	9	1,49	5	1,24
8	6	1,83	8	1,97	6	1,82	14	—	—	3	1,37	—	—
							15	—	—	4	1,29	—	—
							16	—	—	3	1,24	—	—

---

[a] The x-ray was performed by N. A. Sharina in the soil mineralogy laboratory of the Dokuchayev Institute.

Note: Comma represents decimal point.

Table 3

Total chemical composition of colloidal clay fraction of southern chernozems
(% of ignited carbonate free weight sample)

Profile No.	Depth, cm.	Ignition losses	Humus	SiO_2	R_2O_3	Al_2O_3	Fe_2O_3	P_2O_5	CaO	MgO	$\frac{SiO_2}{R_2O_3}$
		%									
1 LA	0—10	14,19	6,2	57,50	36,24	29,65	6,38	0,21	1,34	2,88	2,91
	30—40	12,85	5,2	57,79	38,24	33,03	4,95	0,26	0,85	2,53	2,76
	90—100	9,90	2,12	61,40	35,22	28,35	6,70	0,17	0,43	2,30	3,20
11 LA	0—10	21,8	3,5[a]	58,82	37,85	29,77	7,0	0,28	0,46	1,18	2,88
	50—60	18,1	2,8[a]	58,17	36,81	29,67	6,9	0,24	0,48	2,09	3,13
	190—195	19,5	1,0[a]	59,25	36,38	29,32	7,0	0,06	0,19	3.10	3,19
24 NS	0—10	21,0	3,8[a]	55,95	39,60	33,50	5,95	0,15	0,19	1,63	2,52
	45—55	19,8	3,1[a]	55,49	39,60	31,36	8,10	0,14	0,29	3,47	2,70
	140—150	17,7	1,2[a]	57,35	40,83	33,38	7,32	0,13	0,21	2,87	2,64

[a] Air-dry weight samples

Note: Comma represents decimal point.

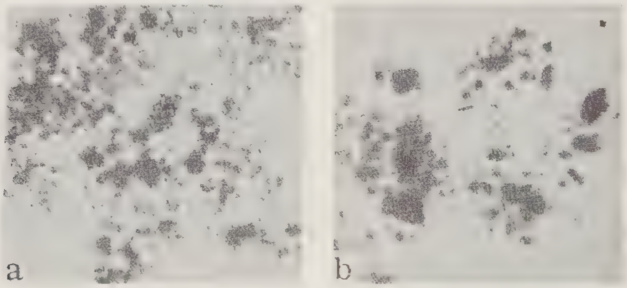


Fig. 2. - Electron-microscope pictures of colloidal clay fraction.
Section 1 LA: a - depth 0-10 cm; b - 90-100 cm.

Recently, the electron microscope has been ccessfully used for investigating colloidal ctions. It gives up to 25,000 x direct magni-ation and the picture can be enlarged 100,000 ıes photographically (3, 4).

Our electron microscopic investigations of colloidal fraction were performed with the p of a GOI electron microscope (Leningrad). e enlargement was small (395) and the tage 650 kW.[3]

Figure 2 shows the electron microscopic tures of minerals contained in a suspension he colloidal clay fraction isolated from the 0 cm and 90-100 cm layers (profile 1 LA). ny amorphous substances can be seen in h pictures, together with a small amount of hydromicaceous minerals, quartz grains, and a large amount of minerals of montmorillonite type which have a loose, spreading shape owing to the highly hydrophilic and mobile character of the crystal lattice.

The electron microscopic analysis data thus indicate the presence of a mineral of the montmorillonite group. Investigations into the physical and chemical properties of the clay fraction and of the soil as a whole help us to define the species of this mineral more precisely.

Certain physical and chemical indices are given in Table 4. The adsorption capacity of the colloidal clay fraction varies from 45-65 meq per 100 g of soil. This corresponds to the adsorption capacity of beidellite.

According to Gorbunov's figures (12), the adsorption capacity of montmorillonitic clays varies between 74 and 112 meq, that of beidellite between 55 and 65 meq, and that of minerals of

---

The electron microscopy work was done by Ye. M. enets in the soil mineralogy laboratory of the uchayev Soil Institute.

Table 4

Physical-chemical characteristics of southern chernozems

Profile No.	Depth, cm	Maximum swelling, %	Moisture, %				Amount of clay fraction, %	Adsorption capacity of colloidal clay, meq per 100 g
			At maximum swelling	Hygroscopic	Maximum hygroscopic	Maximum molecular		
1	0—10	14,5	62,2	6,16	12,10	—	48,42	65,8
	30—40	8,5	59,5	5,93	11,20	—	48,97	65,4
	90—100	5,9	47,7	4,60	8,19	—	41,67	53,0
11	0—10	22,4	58,5	6,57	15,95	24,4	33,6	46,2
	50—60	16,3	—	5,45	15,83	28,0	37,7	44,9
	190—195	21,8	—	7,76	18,97	—	52,68	45,6
24	0—10	17,0	56,2	5,67	13,00	19,8	39,4	58,5
	45—55	19,3	51,0	5,13	12,80	19,7	34,2	60,5
	140—150	11,8	50,8	3,79	10,00	13,1	37,6	51,5

Note: Comma represents decimal point.

the kaolinitic group between 15 and 24 meq per 100 g of the colloidal fraction (<0.001 mm in diameter).

The soil moisture categories (Table 4) — maximum hygroscopic and maximum molecular — also indicate that minerals possessing high water retention capacity are present in the soil. Analyzing the material obtained by earlier methods we conclude that the active colloidal clay part of the soil's adsorption complex in the Crimean chernozems consists mainly of a mineral of the montmorillonitic group, namely beidellite.

There are at present a number of objections to classifying beidellite as a mineral in its own right. Vikulova (4), classifying minerals by type of structure, lists beidellite, together with monothermite, as a mixed-layered (irregular) mineral aggregate. Zvyagin (20) classes beidellite separately as an aggregate formation of variously structured components from two-story and three-story layers.

Since beidellite is in many authors' opinion a mineral aggregate, Grim (17) has proposed rejecting the name beidellite altogether. Gorbunov (16) suggests that this term be kept but confines its meaning strictly to a mineral with certain definite signs: 1) there is a d = 9.8 Å line on the beidellite X-ray photograph and a d = 14 Å line on the montmorillonite X-ray photograph; both lines are diffused; 2) the second endothermal peak occurs at 520-560°C in the case of beidellite, but above 600°C in the case of montmorillonite; 3) the <0.001 mm diameter fraction of beidellite has a cation adsorption capacity of about 60 mg per 100 g against 80-120 meq per 100 g of the fraction in the case of montmorillonite; and 4) the SiO_2:R_2O_3 molecular ratio is roughly 3 in beidellite against more than 4 in montmorillonite.

The strong tendency of Crimean chernozems to shrink, with the formation of deep cracks, during the dry season of the year, probably can be explained only by the presence of minerals with the properties described previously. Nevertheless, despite the poverty of chernozems in organic matter (3%-5% humus) they possess comparatively high fertility. The high adsorption capacity as a result of the presence of beidellite makes for the fixation of a large number of plant nutrients. The capacity of the colloidal clay fraction to swell heavily enables the soil to retain up to 60% moisture (Table 4). As a result, crop failures from drought are comparatively rare in the Crimea, one good rain being sufficient to ensure the harvest.

Received April 11, 1960

BIBLIOGRAPHY

1. ANTIPOV-KARATAYEV, I. N. 1930. Soil colloids and methods of studying them. Tr. VASKhNIL, Leningrad.

2. AFANAS'YEVA, YE. A. 1947. The origin, composition, and properties of chernozems. Tr. Pochv. in-ta. Genezis' i geogr. pochv. Vol. 25.

3. VIKULOVA, M. F. 1952. Use of the electro microscope in studying the structure and composition of finely dispersed rocks and minerals. Tr. VSEGEI, 2.

4. VIKULOVA, M. F. 1956. The present state and lines of development of methods for the mineralogical study of clays. Books 3 and 4, Problems in the Mineralogy of Sedimentary Habits. L'vov.

5. GEDROYTS, K. K. 1934. A study on the adsorption capacity of soils. Sel'khozgiz.

6. GORBUNOV, N. I. 1956. The pattern of

formation and distribution of clay minerals in soils. Books 3 and 4, Problems in the Mineralogy of Sedimentary Habits. L'vov.

GORBUNOV, N. I., I. G. TSYURUPA, and YE. A. SHURYGINA. 1952. X-ray patterns, thermograms, and drainage curves in soils and clays. Moscow.

GORBUNOV, N. I. and YE. A. SHURYGINA. 1956. Heating curves for minerals found in soils and rocks. Pochvovedeniye No. 6.

GORBUNOV, N. I. 1957. Advances in the study of highly dispersed soils. Pochvovedeniye, No. 10.

GORBUNOV, N. I. 1950. Methods of separating soils and clays into fractions for X-ray and thermographic study. Pochvovedeniye, No. 7.

GORBUNOV, N. I. 1959. The importance of minerals for soil fertility. Pochvovedeniye, No. 7.

GORBUNOV, N. I. 1955. Clay minerals of chernozems, chestnut, and solonetz soils. Pochvovedeniye, No. 11.

GORBUNOV, N. I. 1948. The adsorption capacity of soils and its nature. Sel'khozgiz.

GORBUNOV, N. I. and N. YE. BEKAREVICH. 1951. The nature of the formation of the soil crust and ways of countering it. Pochvovedeniye, No. 4.

GORBUNOV, N. I. 1952. Minerals of the fine fraction in soils, their distribution pattern, and methods of studying them. Pochvovedeniye, No. 10.

GORBUNOV, N. I. 1956. Distribution patterns of clay minerals in the main soil groups of the Soviet Union. Pochvovedeniye, No. 2.

GRIM, R. E. 1959. The mineralogy of clays. Translated from the English by B. Ye. Zvyagin, ed. V. A. Frank-Kamentskiy I. L. L.

18. GUSEV, V. P. and V. T. KOLESNICHENKO. 1955. Soils of the Crimean State Joint Agricultural Experimental Station and adjacent regions. Tr. Krymsk. kompl. s-kh. opytn. st., Vol. 1.

19. DZENS-LITOVSKAYA, N. N. 1952. Geographical features of soil formation in the Crimean steppe. Vest. Leningr. gos. un-ta, 7.

20. ZVYAGIN, B. B. 1956. Determination of the clay minerals by electronography. Books 3 and 4, Problems in the Mineralogy of Sedimentary Habits. L'vov.

21. KLEPININ, N. N. 1934. Soils of the Crimea. Simferopol.

22. POPOVA, T. V. 1956. Characteristics of Crimean steppe chernozems. Pochvovedeniye, No. 11.

23. RODE, A. A. 1938. Dispersion capacity of the solid soil mass; chemical and mineralogical composition of this mass and its individual components. Pochvovedeniye, No. 2.

24. SOKOLOVSKIY, A. N. 1949. Some phenomena associated with the colloid part of soils. Izv. Petrovskoy s.-kh. akad., 1-4.

25. SOBOLEV, S. S. 1932. Soils of the Ukraine and Crimean steppe. In collection: Soils of the USSR, part III, USSR Acad. Sci. Press.

26. SHURYGINA, YE. A. 1953. Mineralogical characteristics of the colloidal clay fraction of Kamen steppe chernozems. In: Problems of travopolye farming, vol. 2, USSR Acad. Sci. Press.

27. SHURYGINA, YE. A. 1958. Artificial mixtures of minerals in the thermoanalysis of soils. Tr. Pochv. in-ta, 53.

EFFECT OF ETHYLENDIAMINE TETRAACETATE ON THE BEHAVIOR OF COBALT IN SOIL AND PLANTS

N. V. KULIKOV, Institute of Biology, Ural Branch, Academy of Sciences, USSR

The use of complex-forming substances in biological research is associated primarily with the widespread application of complexones (substances which in combination with metals give readily soluble intra-complex compounds) in the removal of heavy metals and emitters which have penetrated human and animal organisms (4-8).

Another field in which complexones are used and which lately has been attracting the attention of investigators is—as a factor making certain microelements from the soil more readily available to plants. The problem of enhancing the effectiveness of microfertilizers is obviously very important to the nation's agricultural economy, particularly in regions where the soil is, for one reason or another, poor in microelements. Research in this field has shown that the use of iron and zinc complexonates as top dressings does increase the intake of these elements by plants. This has made it possible to wage a successful war on the serious fruit-tree disease of lime chlorosis, for which some countries have started to produce a new type of fertilizer, the chelates (14-18). The number of papers on various complexones in the soil and plants, and their influence on the availability on a number of other mineral nutrients to plants, grows year by year (12, 13, 19, 20, 21).

Lastly, complexones have recently begun to be used in work on radiation biogeocenology as a factor affecting the fate of radioisotopes introduced into this or that habitat of living organisms. The earliest work on aquatic organisms showed that the introduction of a complexone such as EDTA into the habitat reduced the coefficients for the accumulation by these organisms of most radioisotopes studied. The exception, however, was Sr^{90} and Cs^{137} which accumulate more strongly in the presence of EDTA (1, 9, 10).

The present article gives data on the influence of sodium salt of ethylendiamine tetraacetic acid (Na-EDTA) on the behavior of cobalt in the soil and in plants. The work formed part of the general plan of research in our laboratory on radiation experimental biogeocenology (2, 11).

The experimental plants were oats and vetches. These differ as to rate of Co^{60} accumulation from the soil (3). A meadow chernozem-like soil from a well cultivated plot was used (pH 6.6; humus, Tyurin method, 12.6%). The influence of Na-EDTA on plant growth and plant accumulation of cobalt as a function of the amount form, method, and time of adding the complexone to the soil was studied. To this end the following series of experiments was adopted: 1) soil + Co; 2) soil + Co-EDTA; 3) soil + Co + Na-EDTA-powdered; 4) soil + Co + Na-EDTA solution; 5) soil + Na-EDTA solution + Co; and 6) (soil + Co) + Na-EDTA solution applied as liquid after 10-day germination. For the purpose of comparing the influence of the cobalt and various amounts of complexone present in the soil on plant growth a control consisting of plants grown in soil to which the above-mentioned agents had not been applied was used for all 6 treatments of the experiment. The experiment was performed in pot containing 2 kg of air-dry soil. The cobalt, labelled with radio-active Co^{60}, was added into the soil before sowing in the form of $CoCl_2$ solution, except in the second treatment where it was applied in the form of a solution of the ready-made Co-EDTA complex. Radioactivity of the emitter added amounted to 140 microcuries per pot for a cobalt content of 1.09 mg. The amount of complexone varied from 20 to 3,000 mg per pot in the different treatments of the experiment. The plants were harvested 70 days after the beginning of the experiment, dried to constant weig and weighed. To measure the radioactivity of the plant tops and the root system we prepared ash samples and measured the radioactivity of these with a B-2 apparatus under a BFL-T-25 counter. All soil filtrate passed through the pot from rain and watering during the growth period was collected in specially designed trays, measured, and examined for radioactivity.

Observations on the plant growth and the data obtained at the end of the experiment (Table 1) showed that vetch was more sensitive to large amounts of EDTA than oats, which even with very large amounts of the complexone (3,000 mg per pot) remained in excellent condition, whereas even 600 mg caused the vetch to lose 35% of its top weight as compared with the control by the end of the experiment, while 3,000 mg delayed the appearance of shoots for 2 or 3 days. The plants in these treatments were stunted, numerous brown patches formed on the surface of the leaves and the edges of the leaves darkened and curled. By the end of the experiment the weight of these plant tops was only one-sixth that of the control. With small amounts of

Table 1

Dry weight of plant tops in different treatments of the experiment (grams per-pot)

Treatment	Amount of complexone, mg	Oats	Vetch
1. "Pure" control	0	7,76	5,46
2. Co (control)	0	8,26	5,34
3. Co as EDTA	20	8,26	5,22
4. Co + powdered EDTA	125	—	5,66
	600	—	4,60
5. Co + EDTA solution	20	8,80	5,12
	600	9,00	3,54
	3000	8,84	0,84
6. EDTA solution + Co	20	9,26	5,36
	600	9,24	3,80
	3000	11,00	0,66
7. Co - before sowing EDTA - after 10-day germination	20	8,40	6,32
	3000	9,06	1,18

A the experimental plants were ultimately
fferent from the control plants.

ıble 2 gives values for the radioactivity of
ops and the roots of the experimental
s together with the radio-activity of 1 ml
il filtrate for all treatments of the experi-
. Above all, these values show a distinct
ence in cobalt accumulation between the 2
es of plants, particularly in the EDTA
ments. Whereas the cobalt intake by the
increased roughly 10-15 times under the
ıce of the complexone, only 4-6 times more
ccumulated in the oats as compared with
ontrol. This was probably due to the dif-
ces already mentioned regarding the
tivity of the 2 species to the application of
amounts of complexone in the soil. The
s also show (treatments 4 and 5) that the
nce in which the complexone and emitter
applied to the soil did not cause substantial
tions in the behavior of the radioactive co-
s regards either its intake by the plants or
cretion with the soil filtrate. The biggest
on the behavior of the emitter in the soil-
system was caused by the application of
eadymade Co-EDTA complex to the soil.

Twenty mg of the complexone applied by this method, while not in the least inhibiting the growth of the plants, increased the intake of radio-cobalt by the tops of the vetch 15 times, by the roots 8 times, and by the soil filtrate 130 times as compared with the control. The influence of excess Na-EDTA in the original solution on the intake of Co^{60} by the plants and soil filtrate was therefore studied in a specially set up experiment with the vetch. An initial Co-EDTA solution was applied to the soil before sowing, the molar ratio of complexone to cobalt being 1:1 in the first treatment, 5:1 in the second, 25:1 in the third, and 125:1 in the fourth, which meant that there were 5, 25, 125, and 625 mg of complexone, respectively, in each pot or to each 2.0 kg of soil. The principal results of this experiment are shown in Table 3.

These values show that the application of the Co-EDTA complexonate sharply increased the intake of cobalt from the soil by the plants and its secretion into the soil filtrate in all treatments. That the radioactivity of the filtrate does not depend on the amount of complexone is shown by the high stability of the Co-EDTA complex in the soil and the very poor capacity of complexed

Table 2

Radioactivity of main parts of oats and vetch and 1 ml of soil filtrate as a function of form, amount and method of applying the complexone to the soil. (counts per min per g of dry substance and per ml)

Treatment	1 Co control	2 Co-EDTA	3 Co + powdered EDTA		4 Co + EDTA			5 EDTA + Co			6 Co before sowing, EDTA after 10-day germ.	
Complexone amount in mg per experiment pot		20	125	600	20	600	3000	20	600	3000	20	3000
Oats												
Tops	90	560	—	—	100	230	290	120	320	430	90	300
Roots	4720	4210	—	—	5080	3210	3370	4650	2980	3060	5670	5730
Vetch												
Tops	510	7950	3950	6930	1730	6080	8760	1500	7680	7640	700	4070
Roots	2870	23 790	7150	18 850	8450	13 830	12 580	5030	14 400	15 880	4300	9280
Soil filtrate	16	2090	570	1230	415	1670	1920	280	1 900	2360	90	1140

cobalt to exchange with cations of the soil solution. This is well corroborated by experiments on the sorption of complexonate of radioactive cobalt by soil from an aqueous solution containing excess complexone, of varying molar rate, in relation to the emitter. Whereas 96.8% of the uncomplexed form of the emitter was taken up by the soil sample, 100% of the Co-EDTA complex remained in the soil solution even at equimolar cobalt—complexone ratios. This also accounts for the lack of relationship, mentioned previously, between the secretion of Co^{60} into the soil filtrate and the amount of the complexone applied to the soil. The values in Table 3, however, show that if the amount of EDTA applied to the soil is increased, the intake of radiocobalt by the plants, while remaining higher as compared with the control, nevertheless decreases appreciably as compared with the first treatment, where the amount of complexone precisely corresponded to the amount of cobalt. The ratio of root to top radioactivity is also seen to decrease.

By way of a first approximation the pattern noted could be explained either on the hypothesis that free EDTA entering the plants does not allo any part of the radioisotope to be retained in the plant tissues and that it is secreted back into the medium in the form of a complex with the emitte or on the hypothesis that excess EDTA in the soi forms readily soluble complexes with other meta which begin to compete with the Co-EDTA on entering the plant from the soil solution.

To verify these preliminary hypotheses specially set up experiments were performed in water culture.

Table 3

Radioactivity of vetch and soil filtrate (counts per min per g dry substance and per ml) and ratios of radioactivity of various parts of plants in relation to molar ratios of complexone and cobalt in original solution

Sample examined	Co control	Co-EDTA EDTA to Co ratios in solution 1 : 1	5 : 1	25 : 1	125 : 1
Tops	460	7900	6420	6300	5600
Roots	5320	58 760	40 000	22 200	15 810
Soil filtrate	7	1070	1180	1080	1190
Roots: tops	11,6	7,4	6,2	3,5	2,8
Leaves: stalks	2,3	2,8	3,2	3,5	2,5

Table 4

Radioactivity of one vetch plant at the moment of transplantation and after 10 days in pure nutrient solution (counts per min)

Radioactivity of plant	Co-control	Co-EDTA			
		EDTA to Co ratio in solution			
		1 : 1	10 : 1	100 : 1	1000 : 1
Before transplanting into pure solution	2030±6	637±11	300±2	164±30	52±8
After growing in pure solution	1790±270	665±24	425±63	188±12	43±3

Table 5

Radioactivity of total biomass and individual parts of plants in experiment on isolated nutrition (counts per min per g dry substance)

Parts of plant	Treatment			
	Co^{60}-water	Co^{60}-EDTA-water	Co^{60}-EDTA	Co^{60}-EDTA-EDTA
Whole plant	177 220	67 040	162 780	76 070
Tops	40 030	9310	39 370	4180
Roots in radioactive part of solution	886 840	351 525	982 240	469 595
Roots in pure part of solution	55 930	43 025	19 890	6140

In one series of experiments, vetch plants re grown for the first 10 days in lake water h radiocobalt at various molar ratios of com- xone to cobalt. During the next 10 days these nts were transplanted to clean water after eful washing of the root system. One part of plant was investigated for radioactivity be- e transplantation to the pure solution, and other after growing for 10 days in this solu- n. At the end of the experiment the entire ution in which the radioactive plants had own was evaporated to a predetermined ume and then studied for radioactivity. In a econd test, vetches were grown for 20 days such a way that one part of the root system s continuously in a radioactive solution con- ning Co^{60} or Co^{60}-EDTA, while another part s in pure water or non-radioactive solution of TA. At the end of the experiment, the radio- ivity of the different parts of the plants and of pure half of the nutrient solution were asured.

The experimental results showed that the iocobalt taken up by the plants from the water ution was secreted little by the plants into the dium, whereas the complexed form of the itter taken up by the plants was retained as firmly in the plant tissues as its ionic form. Excess EDTA in the nutrient medium reduced cobalt accumulation by the plants but did not foster its secretion from the plant into the surrounding medium.

Table 4 gives the values for the radioactivity of the vetches up to the moment of their transplantation from the radioactive solution and after 10 days' growth in a pure nutritive medium. As can be seen, the radioactivity of a single plant during the growth period in the medium free of radioactivity did not really change in comparison with the initial value in any of the treatments. As a result, the nutrient solution remained practically pure at the end of the experiment. In addition, the values in Table 4 show that the complexed form of the radiocobalt was accumulated from the aqueous solution by the plants less readily than the cobalt in the form of ions in the solution. With increased amounts of EDTA in the nutrient medium the radioactivity of the plants steadily decreased, as in the experiments with soil cultures (see Table 3). As the results of this experiment showed, the reduction cannot be attributed to more intensive secretion of cobalt from the plants. It can be assumed, as we have indicated previously , that it is connected with the formation of free

EDTA molecules or their complexes with other cations capable of competing with the Co-EDTA on being taken up by the plants, when there is an excess of the complexone in the medium. The probability of Co-EDTA intake by the plants will then diminish as the quantity of competitive compounds in the medium increases, as we observed in the experiment. This is a possible first hypothesis and cannot be regarded as final, but the very fact that the intake of radiocobalt by the plants falls when the EDTA amount in the medium is increased, must be considered particularly if cobalt chelates are to be used as microfertilizers. Excess of complexone in the fertilizers in relation to the microelement amount can reduce the efficacy of these fertilizers appreciably.

We have already noted that complexed radiocobalt from aqueous solution is taken up by plants less readily than cobalt applied to the water in the form of chloride. These data are in good agreement with experiments in studying the accumulation coefficients for Co^{60} and other emitters by fresh water organisms, where it was shown that the Co^{60} accumulation coefficients decreased when EDTA was present in the medium (1, 9, 10). Under soil crop conditions we observed that the intake of this isotope by plants increased under the influence of EDTA. This could be because the complexed form of Co^{60} is taken up little by the adsorption soil complex, as the experiments showed, and remains in the soil solution, where it is more readily available to plants, since cobalt applied to the soil in the form of chloride is almost completely converted into a non-exchangeable, poorly mobile form and becomes barely available to plants.

Table 5 gives the principal results of experiments on isolated plant nutrition. One part of the root system of these plants (roughly half the total root mass) was kept continuously for 3 weeks in a radioactive solution with Co^{60} or Co^{60}-EDTA and the other part in pure water or non-radioactive EDTA solution. When the pure half of the nutrient solution was analyzed for radioactivity at the end of the experiment, it was found, as in the preceding experiment, that no radiocobalt taken up by the plants had been secreted into the medium, although the roots in the pure half of the solution had roughly the same radioactivity as the plant top. As in the experiment described previously, the complexed cobalt was accumulated by the plants at a rate several times lower than cobalt applied in the form of chloride.

As part of the plan of biogeocenological research, the experiments described in the present paper are interesting in that they offer a possibility of drastically changing the behavior of such a biologically important chemical element in a soil—soil solution—plant system by the application of a complexone, particularly in an EDTA. From being poorly mobile in the soil and barely available to plants under ordinary natural conditions, this element in complexed form moves freely with the soil solution and is taken up by plants at a ten times higher rate. The results obtained indicate that there are promising possibilities for the agricultural use of cobalt chelates with EDTA as microfertilizers.

Conclusions

1. Experiments on the influence of sodium salt of ethylendiamine tetraacetate on the behavio of radioactive cobalt in the soil and in plants have shown that Co^{60}-EDTA is hardly adsorbed by the soil adsorption complex and shows poor capacity for exchange reactions with soil solution cations. The intake of Co^{60} by plants is enhanced owing to its improved mobility in the soil when combined with EDTA.

2. If the complexone amount in the medium is increased, the intake of radiocobalt from the soil by plants falls in comparison with the treatment in which the complexone amount exactly corresponds to the weight of the cobalt, even though it remains high as compared with the control.

3. Specially set up experiments on isolated nutrient showed that this effect cannot be explaine as a result of more intensive secretion of cobalt from the plant organism back into the medium. The complexed form of radiocobalt was accumulated from water solution by plants less well than cobalt applied in the form of chloride.

4. Vetch proved considerably more sensitive than oats to high amounts of EDTA. Small amounts, while enhancing the intake of Co^{60} by the plants did not exert a predominant influence on their growth.

5. The results obtained point to the possibility of using cobalt chelates with EDTA as cobalt microfertilizers.

Received March 8, 1960

BIBLIOGRAPHY

1. GETSOVA, A. B., YE. A. TIMOFEYEVA-RESOVSKAYA, and N. V. TIMOFEYEV-RESOVSKIY. 1960. The influence of EDTA on the accumulation of various radioisotopes from water solution by leaches and mosquitos. Doklady Akad. Nauk SSSR, Vol. 130, No. 2.

2. KULIKOV, N. V. 1957. The action of uraniu fragments on the biomass and structure of an experimental phytocenosis. Bot. zh., Vol. 42, No. 377.

3. KULIKOV, N. V. 1960. The accumulation of radioactive cobalt by a phytocenosis from various depths and horizons of the soil. Byul. Ural. otd. MOIP, 3.

4. SEMENOV, D. I., and I. P. TREGUBENKO. 1957. The influence of complexones on the behavior of metals and emitters in the organism. Sb. Tr. labor Biofiz. UFAN SSSR, No. 1, Sverdlovsk.

5. SEMENOV, D. I., and I. P. TREGUBENKO. 1958. The action of complexones on the deposition of radioactive yttrium, radioactive cerium, and plutonium in tissues, and their secretion from the organism. Biokhim., Vol. 23, No. 1.

SEMENOV, D.I. 1958. The influence of EDTA on cation exchange in the organism. Author's abstract of thesis. In-t biol. UFAN SSSR, Sverdlovsk.

SEMENOV, D.I. 1958. The influence of complexones on the behavior of emitters in the organism and the mechanism of action of complexones. Byul. Ural. otd. MOIP, 1. Sverdlovsk.

SEMENOV, D.I. 1959. Complexones in biology and medicine. Priroda, 8.

TIMOFEYEVA-RESOVSKAYA, YE. A. 1959. Influence of EDTA on the strontium, ruthenium, cerium, cobalt, zinc and cesium accumulation coefficients. Proc. conf. on complexones. Sverdlovsk.

TIMOFEYEVA-RESOVSKAYA, YE. A., and N. V. TIMOFEYEV-RESOVSKIY. 1960. Influence of ethylendiamine tetraacetate on the accumulation coefficients of various radio isotopes from water solution by fresh water plants. Dokl. Akad. Nauk SSSR, Vol. 130, No. 1.

TIMOFEYEV-RESOVSKIY, N. V. 1957. Application of radiations and emitters in experimental biogeocenology. Bot. zh. Vol. 161, No. 42.

ANTONINI, I. 1954. Iron chelates control iron chlorosis. Agric. Chemicals, Vol. 9, No. 11.

BEAR, F. E. 1957. Chelates in plant nutrition. Soil Sci., Vol. 84, No. 1.

14. BOULD, G. 1955. Chelates iron compounds correct lime-induced chlorosis in fruit crops. Agric. Rev., Vol. 1, No. 1.

15. HIGDON, R.I. 1956. Chelates for iron chlorosis. West Fruit Grower, Vol. 10, Chap. 2, 21.

16. KROLL, H. 1957. The ferric chelate of ethylenediamine di (o-hydroxyphenylacetic) acid for treatment of lime-induced chlorosis. Soil Sci., Vol. 84, No. 1.

17. STEWART, I., and C.D. LEONARD. 1956. Iron chelates. Farm Chemicals, Vol. 119, No. 10, 46.

18. STEWART, I., and C.D. LEONARD. 1957. Use of chelates in citrus production in Florida. Soil Sci., Vol. 84, No. 1, 87.

19. STEWART, I., and C.D. LEONARD. 1958. Use of isotopes in determining the availability to plants of intracomplex compounds of metals. Internat. Conf., Geneva, Aug. 1955, Vol. 12, p. 192, Moscow.

20. WALLACE, A., L. SHANNON, O.R. LUNT, and R.L. IMPEY. 1957. Some aspects of the use of metal chelates as micronutrient fertilizer sources. Soil Sci., Vol. 84, No. 1, p. 27.

21. WALLACE, A., C.P. NORTH, R.T.MULLER, L.M. SHANNON, and N. HEMAIDAN. 1955. Behavior of chelating agents in plants. Proc. Amer. Soc. Hortic. Sci., Vol. 65.

BIOLOGICAL ACTITY OF FOREST SOILS IN THE KOLA PENINSULA

A. L. PARSHEVNIKOV, Institute of Forestry and Forest Chemistry, Academy of Sciences, USSR, Arkhangel'sk

It is common knowledge that soil carbon dioxide plays an important role in the life of plants and soils. The rate of decomposition of organic matter can be assessed and the biological activity of soils characterized from the amount of carbon dioxide evolved from the surface of the soil (11, 12, 3, and others).

A great deal of material descriptive of soil respiration and the biological activity of the soil in different soil and climatic zones and under different vegetation has been accumulated in Soviet and foreign literature (1, 2, 4, 5, 6, 7, 8, 9, 10, 14, 15, 16). The publications of Mina, Zonn and Aleshina, and Smirnova are of great value for their description of the biological activity of soils in plantations of various species and age composition growing on different soils. Nevertheless, there are no data on soil respiration within the Arctic circle and, in particular, in the Kola peninsula.

In the summer of 1958 we carried out experiments to determine the biological activity of soils by measuring the carbon dixoide evolved from the surface. The following plantations and cutting areas were investigated:

1. Spruce with bilberry. Composition - 7 Fir, 3 Birch + Pine, age 180 years, density 0.8, site quality V. Undergrowth occasionally spruce. Green mosses and bilberry at ground level.

2. Conditional clear cutting of spruce with bilberry. Composition of the stand remaining after cutting - 2 Spruce, 8 Birch, age 170 years, density 0.3, site quality V. Spruce and birch undergrowth. Green mosses, bilberry, bog bilberry, and wild rosemary at ground level, patches of haircap moss. Site - a slight, level elevation.

3. Pine with moss and lichen. Composition 8 Pine, 2 Fir + Birch, age 140 years, density 0.8, site quality V. Undergrowth very sparse and consisting of spruce. Bilberry, red bilberry, crowberry, and wild rosemary at ground level; Pleurozium Schreberi is the commonest moss and there are patches of lichen.

4. Clear cutting of pine stand with moss and lichen in the previous year. Bordering on moss and lichen pine wood. Green mosses, crowberry, bilberry, bog bilberry, wild rosemary, heather, and lichens at ground level. Site - center of gentle slope to stream.

The soil beneath the spruce stand with bilberry and on the conditional clear-cut area was a shallow sandy loam podzol underlain by morain clay loam. The soil was highly acid, the pH of a water suspension being 4.5 in the A_0 horizon, 4.7-4.9 in the A_2 horizon. Acidity decreased with depth: the pH of the C horizon being 5.5 beneath the spruce stand and 6.0 in the clear-cut area.

Exchangeable acidity determined by Sokolov's method was 5.90 meq in the A_0 horizon in the clear-cut, and 6.84 meq beneath the spruce, while the corresponding figures for the A_2 horizo were 1.61 meq and 1.83 meq per 100 g of soil. Total exchangeable bases in the A_0 horizon is nearly 20 meq, in the A_2 horizon, 0.7 meq per 100 g of soil. Unsaturation was high in the upper soil horizons (54%-72%). Available phosphorus and potassium compounds were present in considerable quantities only in the litters (up to 28 mg of P_2O_5 and 105 mg of K_2O per 100 g of soil): their content in the mineral horizons was slight. In the A_2 horizon 100 g of soil contained 1.2-1.6 mg of P_2O_5 and 5.2-7.0 mg of K_2O. Humus content varied within the profile from 0.39% to 1.54%.

The soil beneath the pine forest with moss and lichen and on the adjacent area that had been cleared in the previous year was a shallow sandy podzol of a coarser texture. Approximately 8% of the particles were smaller than 0.01 mm in diameter. Chemical analysis showed that the litters were more acid than in the spruce stand. Thus, pH in the A_0 horizon was 3.7 beneath the pine forest and 3.9 in the clear-cut area. The hydrolytic acidity of the litter also was very high especially in the clear-cut area (160 meq per 100 g of soil). Exchange acidity was somewhat lower than in the spruce soil. Total exchangeable acidity by Sokolov's method was 2.47 in the A_0 horizon in the clear-cut area and 3.67 meq per 100 g of soil beneath the pine canopy. The corresponding figures for the A_2 horizon were 4.5 and 5.6 meq per 100 g of soil.

The content of exchangeable bases was approximately 20 meq in the A_0 horizon and 0.2-0.6 meq per 100 g of soil in the A_2 horizon. In the deeper soil horizons the content of exchangea

Table 1

Biological activity of certain forest soils. CO_2 evolution from 1 m² in 1 hr, mg

Subject	Indices	Date of observations						
		July 7	July 26	July 27	Aug. 10	Aug. 11	Aug. 25	Aug. 26
Spruce with bilberry	a) with litter	197	256	—	—	176	165	—
	b) without litter	190	132	—	—	135	117	—
	Air temperature	15,1	15,7	—	—	13,1	10,4	—
	Soil temperature at 5 cm	5,5	10,0	—	—	9,1	9,5	—
	The same at 10 cm	5,3	8,4	—	—	8,5	8.5	—
	Moisture in A_0 hor.	183,2	321,0	—	—	360,0	177,7	—
	Moisture in A_2 hor.	27,3	26,2	—	—	36,6	28,9	—
Conditional clear-cut spruce with bilberry	a) with litter	238	245	—	—	197	175	—
	b) without litter	208	125	—	—	125	146	—
	Air temperature	15,7	19,7	—	—	14,8	11,0	—
	Soil temperature at 5 cm	8,9	11,7	—	—	11,2	11,5	—
	The same at 10 cm	7,4	10,0	—	—	10,2	10,0	—
	Moisture in A_0 hor.	Not det'd	267,6	—	—	345,9	229,4	—
	Moisture in A_2 hor.	25,5	43,3	—	—	42,0	37,7	—
Pine forest with moss and lichen	a) with litter	—	—	234	153	—	—	241
	b) without litter	—	—	132	66	—	—	190
	Air temperature	—	—	20,3	15,0	—	—	14,4
	Soil temperature at 5 cm	—	—	14,5	10,0	—	—	11,3
	The same at 10 cm	—	—	10,6	9,0	—	—	9,0
	Moisture in A_0 hor.	—	—	376,9	296,6	—	—	124,3
	Moisture in A_2 hor.	—	—	14,5	13,4	—	—	10,1
Conditional clear-cut pine with moss and lichen	a) with litter	—	—	146	125	—	—	110
	b) without litter	—	—	117	66	—	—	81
	Air temperature	—	—	20,5	15,5	—	—	15,2
	Soil temperature at 5 cm	—	—	16,5	11,5	—	—	11,8
	The same at 10 cm	—	—	13,0	10,0	—	—	10,5
	Moisture in A_0 hor.	—	—	338,5	268,7	—	—	164,3
	Moisture in A_2 hor.	—	—	17,9	16,6	—	—	11,7

Note: Comma represents decimal point.

es was considerably lower beneath the pine beneath the spruce. Base unsaturation 52% in the A_0 horizon and 65% in the A_2 zon. There were 17.2 mg of available phosrous per 100 g of soil beneath the pine ppy in the A_0 horizon, 1.7 in the A_2 horizon 4.6 in the B_1 horizon. In the clear-cut area corresponding figures were 18.8, 0.6, and mg per 100 g of soil. There was a great of available potassium (up to 116 mg per g) in the litters and only 8-17 mg per 100 g oil in the podzolized horizon. Humus content low at approximately 0.5% in the A_2 horizon approximately 1.2% in the B_1 horizon. The ent once again decreased in the B_2 horizon.

htatnov's method, (13) as modified by Smir- (9), was used to determine the amount of evolved. Each experiment was duplicated.

The apparatus was set up both in the presence and the absence of litter.

Soil temperature to a depth of 10 cm and air temperature were measured in addition to the amount of carbon dioxide evolved from soil and moisture. All the experiments were conducted between 1000 and 1400 hours.

The results (see Table 1) showed that a considerable amount of carbon dioxide is evolved from the surface of forest soils in the Kola peninsula during the summer months (July and early August). This shows that the biological activity of forest soils is comparatively high.

Evolution of carbon dioxide from the soil surface was greatest at the end of July owing to the favorable climatic conditions—air and soil temperature relatively high and soil quite moist. The evolution of CO_2 declined on all the test plots in the middle of August, but especially in the podzolized horizons of the pine forest with moss and lichen and of the adjacent clear-cut area from the previous year. This decline agreed well with the sharp decrease in air and soil temperature and with some decrease in soil moisture in the pine forest and in the clear-cut area from the previous year. Soil moisture in the spruce stand and in the conditional clear-cut area, on the other hand, increased slightly by comparison with its level on July 26.

At the end of August the amount of CO_2 evolved from the soil surface was even lower beneath the spruce with bilberry canopy and on the conditional clear-cut area, whereas it had risen sharply beneath the pine canopy. There was some increase in CO_2 evolution from the podzolized horizon of the soil in the moss and lichen pine area clear-cut from the previous year, owing to a certain increase in the temperature of the upper horizons of the soil.

In all cases, considerably less CO_2 was evolved from surfaces from which the litter had been removed than from soils with litter. In general, slightly more CO_2 is evolved from the soil surface in pine forests than in spruce stands. This is because pine forest soils contain contain more humus, exchangeable bases, and available phosphorous and potassium compounds than do the soils of spruce stands, and their biological activity is correspondingly higher.

A comparison of our data for the biological activity of the forest soils of the Kola peninsula with Smirnov's data (9, 10) for the soils of the southern region of the USSR's forest zone shows that, in July and early August, the forest soils of the Kola peninsula are in no way inferior to those of the more southerly districts in respect of the amount of CO_2 evolved. On the other hand, conditions favorable to intensive biological activity are created here only in the very brief summer period.

Received February 26, 1960

BIBLIOGRAPHY

1. GORBUNOV, N. I. 1947. Soil air CO_2 and methods for its determination. In the collection: Sovrem. metody issled. fiz-khim. svoystv pochv., Vol. 4, No. 2.
2. ZONN, S. V., and A. K. ALESHINA. 1953. Gas exchange between soil and atmosphere beneath a forest plantation canopy. Dokl. Akad. Nauk SSSR, Vol. 92, No. 5.
3. KONONOVA, M. M. 1951. The problem of soil humus and the scope of present day research. Izd. Akad. Nauk SSSR.
4. MAKAROV, B. N. 1958. Variation in soil respiration and CO_2 content of the ground atmospheric layer in a 24-hour period. Doklady Akad. Nauk SSSR, Vol. 118, No. 2.
5. MINA, V. N. 1949. CO_2 content of the air in forest soils. Doklady Akad. Nauk SSSR, Vol. 64, No. 4.
6. MINA, V. N. 1951. Composition of soil air in forest soils. Tr. In-ta lesa Akad. Nauk SSSR, Vol. 8.
7. MINA, V. N. 1954. CO_2 content of the air in forest soils in relation to the age of the stand. Soobshch. In-ta lesa Akad. Nauk SSSR, No. 2.
8. MINA, V. N. 1957. Biological activity of soils in relation to physico-geographic conditions and stand composition. Pochvovedeniye, No. 10.
9. SMIRNOV, V. N. 1954. Biological activity of afforested soils in the southern part of the taiga zone. Tr. In-ta lesa Akad. Nauk SSSR, Vol. 23.
10. SMIRNOV, V. N. 1955. Interconnection between soil CO_2 evolution and the productivity of forest soils. Pochvovedeniye, No. 6.
11. TYURIN, I. V. 1937. Soil organic matter.
12. SHMUK, A. A. 1950. The dynamics of the nutrients regime in the soil.
13. SHTATNOV, V. I. 1952. Procedure for determining the biological activity of soils. Doklady VASKhNIL, No. 6.
14. KOEPF, H. 1953. Die Temperatur/Zeit-Abhängigkeit der Bodenatmung. Ztschr. Pfl., Düng. u. Bodenk. Vol. 6, No. 1.
15. KOEPF, H. 1954. Die biologische Aktivität des Bodens und ihre experimentelle Kennzeichnung. Ztschr. Pfl., Düng. u. Bodenk. Vol. 67, No. 2.
16. SCHAFFER, Y. 1954. Atmungskurven des Bodens unter dem Einfluss langjähriger, verschiedenartiger Düng. Ztschr., Pfl., Düng. u. Bodenk. Vol. 67, No. 3.

ORMATION OF THE CHEMICAL COMPOSITION OF OIL SOLUTIONS UNDER THE INFLUENCE F GROUND WATER

I. SHAVRYGIN, V. V. Dokuchayev Soil Institute, Academy of Sciences, USSR

The origin of soil solutions is varied and is e to the influence of a number of factors. ere the ground water lies well below the sur- e, soil solutions form mainly as a result of isture from atmospheric precipitation. The ncentration of such soil solutions usually is high; their composition is due to the weather- of various minerals and also to biogenic ocesses.

Where there is capillary moistening from und water the origin of soil solutions is more nplex. Apart from the factors mentioned viously, the ground water plays a part in ir formation and in irrigated regions, irriga- n water as well.

With capillary wetting the increased concen- tion of the soil solutions can be regarded as rocess of gradual evaporation and concentra- n of the ground water. As Kovda (1) has ablished, the increase in the concentration of und-water and soil solutions as a result of ir evaporation is accompanied by an enrich- nt of the water-bearing soil and the soil er in calcium and magnesium carbonates and sum. The process of precipitation of these ts into the solid phase in the soil leads to a luction in the relative content in calcium, O_3^- and SO_4^{--} content in the composition of the l solution, and to an increase in the amounts sodium and magnesium chlorides.

The increase in the concentration of the und-water and soil solutions as a result of ir evaporation is accompanied, apart from precipitation of not readily soluble salts into id phase, by inter-reactions between the ad- ption complex of the soil and the water solu- . Exchange reactions include displacement Ca^{++} and Mg^{++} by Na^+ or the reverse. Pres- e of exchangeable reactions between soil and utions is established by Kovda and Gevel'son with special experiments under laboratory ditions.

With capillary wetting it is of interest to com- e the composition of ground water with that oil solution. It may reveal a series of peculi- processes inter-reacting with ground water the adsorption complex of soil. The method have used to elucidate the proposed question hat suggested by Letunov (4).

As we have indicated previously the concentration of Ca^{++}, Mg^{++}, K^+, HCO_3^-, and SO_4^{--} changes in the process of ground-water evaporation. The absolute chloride content in ground water remains, as Letunov points out, approximately proportional to the degree of evaporation of the initial composition of the ground water. A brief glance at the ground-water analyses arranged in order of magnitude of mineralization makes the truth of this apparent. Letunov used his method to obtain evidence of ground-water salt metamorphism in the lower reaches of the Amu-Dar'ya River. He took the average composition of Amu-Dar'ya water over a number of years as a basis for comparison with the ground waters.

We used this method to obtain evidence of the salt metamorphism of soil solutions under conditions of ground-capillary moistening. For comparison with ground waters it is obviously better to take solutions from soil horizons within the sphere of influence of the ground-water capillary fringe than from the top horizons.

Essentially, the method is as follows. From the Cl^- content in the soil solution one determines the evaporation coefficient, or the number of liters of ground water required to give 1 liter of the soil solution under study. On this basis the ion content (in meq) in the ground water is multiplied by the evaporation coefficient. An excess of particular ions in the soil solution as compared with the original volume of ground water indicates that processes entailing the removal of particular ions from the water-containing material into the solution are occurring. A deficiency of any particular ion in the soil solution indicates transition to the insoluble state on the part of the given ion. This transition can occur through the precipitation of not readily soluble salts which have reached the solubility limit in evaporation of the initial water solution. The content of particular cations in the solution can decrease as a result of exchange reactions with the adsorption complex of the soil. The decrease in quantity of one of the cations, for example Ca, must then be compensated by an equivalent increase in the solution's content in some other cation displaced from the soil.

Since an anion and cation balance must be maintained during the precipitation of non-readily-soluble salts, it is possible to detect an excess of any particular cation by combining the ions which have entered into solution with those which have been removed from it into the salts. The presence

Table 1

Ionic composition of solution of non-saline arable meadow soil as compared with the ground water (Plot 9) Fedchenko experimental field, Central Fergana). (Analytical chemist - T. A. Gevel'son)

Solutions and interactions	meq per liter							dry residue, g per liter
	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	HCO_3^{-}	$SO_4^{=}$	Cl^{-}	
	Depth 25 - 35 cm May 28, 1940							
Composition of soil solution	30,7	78,3	33,7	3,6	3,2	134,2	8,9	9,4
Composition of ground water	25,5	29,2	9,0	1,0	2,9	58,5	3,4	4,4
2. 6 l ground water contains -	66,3	76,0	23,6	2,6	7,5	152,1	—	—
Amounts passing into solid phase of soil from each liter of solu.	35,6	—	—	—	4,3	17,9	—	—
Amounts passing fr. soil to solu.	—	2,3	10,1	1,0	—	—	—	—
	Depth 35 - 65 cm May 28, 1940							
Composition of soil solution	30,7	81,2	32,4	3,6	3,6	137,0	7,3	8,9
Composition of ground water	25,5	29,2	9,0	1,0	2,9	58,5	3,4	4,4
2. 6 l ground water contains -	53,4	61,7	19,0	2,1	6,1	122,8	—	—
Amounts passing into solid phase of soil from each liter of solu.	22,7	—	—	—	2,5	—	—	—
Amounts passing fr. soil to solu.	—	19,5	13,4	1,5	—	14,2	—	—
	Depth 65 - 100 cm May 28, 1940							
Composition of soil solution	29,7	33,0	30,3	4,5	3,1	89,3	5,2	5,6
Composition of ground water	25,5	29,2	9,0	1,0	2,9	58,5	3,4	4,3
2. 6 l ground water contains -	38,2	43,8	13,6	1,5	4,4	87,6	—	—
Amounts passing into solid phase of soil from each liter of solu.	8,5	10,8	—	—	1,3	—	—	—
Amounts passing fr. soil to solu.	—	—	16,7	3,0	—	1,7	—	—

Note: Comma represents decimal point.

of such an excess indicates that exchange reactions are occurring between the soil and the salt composition of the solution.

Detailed calculations in regard to the interaction of soil forming complexes with water solutions are given below. For comparison we took soil solutions from the Central Fergana, the Golodnaya steppe, and the Barabinsk lowlands, separated out by pressure in an apparatus designed by Kryukov (3). A hydraulic lever press was used as the source of pressure. Pressure was raised to 150 kg/cm^2.

It can be seen from Table 1 that the solution of non-saline irrigated meadow soil had a concentration of 5.6 g/liter against 4.3 g/liter for the ground water (Central Fergana). The chloride ion content in the solution was 5.2 meq, against 3.4 meq in the ground water. The observed concentration of the soil solution was consequently the result of evaporation of 1.5 liter of ground water (5.2:3.4 = 1.5). Table 1 shows the ion content in a volume of ground water equivalent in respect of chloride ions. Comparison of the computed amounts with the actual ion composition of the soil solution shows that at the degree of ground-water evaporation indicated, 1.3 meq of calcium bicarbonate has passed into the solid phase of the soil from each liter of solution, against 1.7 meq of sulfates passing from the soil into solution. The exchange reactions of the solution with the adsorption complex of the soil were expressed in the adsorption of 18.0 meq of calcium and magnesium and the precipitation into solution of 18.0 meq of other cations, mainly sodium.

The ionic composition of a solution of the same soil is compared with that of 2.6 liters of ground water in Table 1. From these values we may conclude that 4.3 meq of calcium bicarbonate and 17.9 meq of gypsum have passed into the solid phase of the soil from each liter of solution. The exchange reactions were expressed in the adsorption by the soil of 13.4 meq of exchangeable calcium from each liter of solution and the displacement of an equivalent amount of other cations, mainly sodium.

Comparison of the ionic composition of a solution of the same soil with that of 2.1 liters of ground water indicates that for each liter of solution, 2.5 meq of calcium bicarbonate was precipitated into the solid soil phase from each liter of solution. As a result of exchange reactions the soil has adsorbed 20.2 meq of calcium and precipitated the same quantity of other cations into solution, mainly exchangeable magnesium and sodium; 14.2 meq of sulfates have been precipitated from solution.

Table 2

Ionic composition of solution of non-saline arable meadow soil as compared with ground water (Plot 9. Fedchenko experimental field, Central Fergana)

Solutions and interactions	meq per liter							dry residue, g per liter
	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	HCO_3^{-}	$SO_4^{=}$	Cl^{-}	
	Depth 35-65 cm July 7, 1940							
Composition of soil solution	30,7	50,0	13,1	2,4	3,3	87,7	5,3	6,6
Composition of ground water	27,0	20,6	8,8	1,1	2,8	51,5	3,2	3,8
1. 6 1 ground water contains-	43,2	32,9	14,1	1,7	4,4	82,3	—	—
Amounts passing into solid phase of soil from each liter of solu.	12,5	—	1,0	—	1,1	—	—	—
Amounts passing fr. soil to solu.	—	17,1	—	0,7	—	5,4	—	—
	Depth 65-100 cm July 7, 1940							
Composition of soil solution	33,1	40,8	16,0	2,7	3,1	85,2	4,5	5,8
Composition of ground water	27,0	20,7	8,7	1,1	2,8	51,5	3,2	3,8
1. 4 1 ground water contains -	37,9	28,9	12,0	1,5	3,9	72,1	—	—
Amounts passing into solid phase of soil from each liter of solu.	4,8	—	—	—	0,8	—	—	—
Amounts passing fr. soil to solu.	—	11,9	4,0	1,2	—	13,1	—	—
	Depth 35-65 cm August 10, 1940							
Composition of soil solution	32,0	48,8	9,2	1,9	3,0	85,9	3,0	13,2
Composition of ground water	26,3	21,4	9,0	1,3	2,1	53,6	2,2	3,7
1. 4 1 ground water contains -	36,7	29,9	12,5	1,8	2,9	75,0	—	—
Amounts passing into solid phase of soil from each liter of solu.	4,7	—	3,3	—	—	—	—	—
Amounts passing fr. soil to solu.	--	18,9	—	0,1	0,1	10,9	—	—

Note: Comma represents decimal point.

Table 2 compares the ionic composition of a tion of non-saline irrigated meadow soil that of 1.6 liter of ground water. This parison shows that from each liter of solu- , 1.1 meq of calcium bicarbonate was pre- tated into the solid soil phase and 5.4 meq agnesium and potassium sulfates passed n the soil into solution; 12.4 meq of ex- ngeable magnesium was displaced from the and 11.4 meq of calcium and 1.0 meq of um adsorbed by it.

able 2 also compares the ionic composition solution of the same soil with that of 1.4 of ground water.

rom this comparison it follows that the centration of ground water during evaporation ccompanied by exchange reactions between water solution and the adsorption complex e soil; a transition of readily soluble salts soil to solution has been established but ransition of non-readily soluble salts into solid soil phase was detected.

Table 3 the ionic composition of a solution eadow solonchak is compared with that of liter of ground water (Baraba). Calcula- s show that from each liter of solution 3.0 of calcium bicarbonate were precipitated the solid soil phase and that 7.6 meq of nesium and sodium sulfate passed from the into solution. The volume of exchange reactions amounted to 45.2 meq per liter of solution; 45.2 meq of exchangeable calcium passed into the adsorption complex of the soil and 45.2 meq of other cations, mainly sodium, were displaced into solution to replace it.

Table 3 also compares the ionic composition of a solution of medium saline irrigated sierozem with that of 1.5 liter of ground water (Golodnaya steppe). From each liter of solution 2.8 meq of calcium bicarbonate were precipitated into solid phase. The interaction of the solution with the soil was expressed as the adsorption of 12.0 meq of calcium by the soil and displacement mainly of magnesium from the adsorption complex of the soil into the solution; 2.0 meq of potassium nitrate and 43.5 meq of magnesium and sodium sulfates passed from the soil into solution. Readily soluble sulfates in irrigated soils appear to enter into solution from the fertilizers applied under cultivated cotton. In the irrigated soil of the Golodnaya steppe, not only readily soluble sulfates but also nitrates are observed to pass from the soil into solution.

Such salts are to be found in the solid phase of the Barabinsk lowland meadow solonchak and this explains the transition of readily soluble sulfates from the soil into solution in this case, since the soil under study was strongly salinized. Ground water, rising by capillarity, has dissolved these salts, thereby increasing the readily soluble sulfates in soil solutions formed under

Table 3

Ionic composition in soil solution as compared with ground water

Solutions and interactions	meq per liter						dry residue, g per liter
	Ca^{++}	Mg^{++}	Na^+	HCO_3^-	$SO_4^{=}$	Cl^-	
	Plot 11. Meadow solonchak, depth 90-140 cm September 25, 1944. Ubinsk experimental meliorative station, Central Baraba.						
Composition of soil solution	163,3	216,6	94,9	0,3	47,3	428,7	30,9
Composition of ground water	140,0	142,1	29,9	2,2	26,5	283,4	23,6
1. 5 liter ground water contains -	211,5	214,5	44,2	3,3	39,7	—	—
Amounts passing into solid phase of soil from each liter of solution	48,2	—	—	3,0	—	—	—
Amounts passing from soil to solution	—	2,1	50,7	—	7,6	—	—

Solutions and interactions	meq per liter								dry residue, g per liter
	Ca^{++}	Mg^{++}	Na^+	K^+	HCO_3^-	$SO_4^{=}$	NO_3^-	Cl^-	
	Plot 2. Medium salinized arable sierozem. Depth 20-40 cm, June 26, 1941. Golodnaya steppe.								
Composition of soil solu.	39,2	114,7	63,9	4,7	6,0	152,1	2,9	61,6	14,8
Comp. of ground water	36,0	43,3	39,7	1,9	5,8	72,4	0,6	41,1	7,8
1. 5 liter ground water contains -	54,0	63,5	59,6	2,7	8,8	108,6	0.9	—	—
Amounts passing into solid phase of soil from each liter of solution	14,8	—	—	—	2,8	—	—	—	—
Amounts passing from soil to solution	—	51,2	4,3	2,0	—	43,5	2,0	—	—

Note: Comma represents decimal point.

similar conditions.

Conclusions

1. A higher concentration of ground waters and soil solutions is accompanied by interactions between the adsorption complex of the soil and the water solution.

2. Apart from exchange reactions, a rise in the concentration of ground waters and soil solutions as a result of evaporation usually leads to the passing of calcium and magnesium bicarbonates and gypsum into the solid phase.

3. The interaction of water solutions with the soil is often accompanied by a transition of certain readily soluble salts from the soil into solution.

Received October 16, 1959

BIBLIOGRAPHY

1. KOVDA, V. A. 1946. The origin and regime of saline soils, part 1, Izd-vo Akad. Nauk SSSR.

2. KOVDA, V. A., and T. A. GEVEL'SON. 1951. The importance of the adsorption capacity of soils in forming the mineralization of ground waters. Tr. lab. gidrogeol. problem im. akad. F. P. Savarenskogo, Vol. 9.

3. KRYUKOV, P. A. 1947. Methods of separating soil solutions. In the collection: Modern methods of investigating the physical and chemical properties of soils. No. 2, Izd. Akad. Nauk SSSR.

4. LETUNOV, P. A. 1958. Soil meliorative conditions in the lower reaches of the Amu-Dar'ya. Tr. Aralo-Kasp. kompl. eksped., No. 10.

SE OF INTERFEROMETRY IN SOIL CHEMICAL STUDIES

U. A. POLYAKOV and N. S. GERMOGENOVA, V. V. Dokuchayev Soil Institute, Academy of
iences, USSR

The interferometer described here (the ITR- is designed to study solutions and gas mixres. The design features are described in e manufacturer's leaflet.

Many solutions of various substances can be alyzed by interferometry, without regard to e nature of the solvent and the solute. The ethod is based on the fact that the refractive dices of mixtures are strictly additive, so at the composition of a binary mixture can be ambiguously determined by interferometric adings. This remains true of multi-component stems if the concentration of one component is bitrarily varied while that of the other comnents remains constant.

An interferometer should not be used to alyze colored and turbid solutions and mixres. Although the instrument is highly acrate, it operates, as would be expected, over very restricted range of values of the refracve index n. When working with short cells the merical range of n is given by a few units of e second place, while when working with long lls it is given by a few units of the fourth ace.

Examples of the Practical Use of an Interferometer

Determination of Concentration. Concentraon can be calculated most simply if calibration rves are used. A series of samples in which e concentrations of the solute are known is epared. These samples are compared with a libration standard (distilled water or a salt lution of known concentration). The value of that corresponds to each sample is found on e scale of the drum.

As an example we shall examine the values tained in a determination of NaCl concentraon. These values can be presented as two lumns: the known concentrations of NaCl (C ol/liter) and the experimental values of the fractive index (Δn). If these values are arnged in ascending order of magnitude we obin:

Δn readings from the drum	890	1570	2135	2720	3303	3885	4460	5040	5990	6575
NaCl concentration C mol/liter	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	0.1

The calibration curve $\Delta n = f$ (C mol/liter) given in Figure 1, was constructed from these values.

It is easy to see from the curve that there is a linear dependency between the variables Δn and C mol/liter that, therefore,

$$\Delta n = KC \text{ mol/ liter} \qquad (1)$$

The proportionality coefficient, calculated from the calibration curve, was found to be $K \sim 6500$.

If one has the calibration curve, one can easily find the sought-after concentration C mol/liter from the graph (Fig. 1) or from equation (1), it being only necessary to determine Δn experimentally.

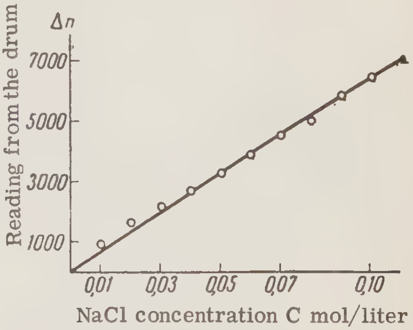


Fig. 1. - Calibration curve for determining NaCl concentration

The example we are considering here is of interest because the solution contained traces of KCl and KNO_3 as well as NaCl.

The concentration of the admixtures did not vary throughout the experiment and they did not, therefore, interfere with determination of the NaCl concentration. The concentration of the

Table 1

Numerical values of dry residues and equivalent values of Δn

Soil and location	Dry residue, %	Change in refractive index Δn	Value of $d = \frac{\Delta n}{\text{dry residue}}$
Light chestnut soil, Arshan'-Zel'men'	1,1	2,64	2,40[a]
The same	1,66	4,0	2,41
" "	0,2	0,48	2,40
Medium-columnar solonetz, Arshan'-Zel'men'	0,7	0,68	2,40
The same	0,4	0,96	2,40
" "	0,9	2,16	2,40
" "	0,7	1,66	2,37
" "	0,3	0,72	2,40
Light chestnut solonetzic soil, Arshan'-Zel'men'	0,62	1,5	2,42
Light chestnut, slightly solonetzic soil, Arshan'-Zel'men'	0,9	2,21	2,45
Solonetz, Dzhanybek	2,3	5,52	2,40
Light chestnut solonetzic soil, Karpov MTS	0,42	1,0	2,38
Solonchak-like solonetz, Dzhanybek	1,6	3,86	2,41
Alluvial, Arshan'-Zel'men'	1,2	2,9	2,42
Northern soils, maritime solonchak at the mouth of the Lena	0,5	1,2	2,40
Grey-br. soil, China	1,04	2,5	2,44
Desert soil, China	0,83	2,0	2,41
Grey-br. solonchak-like soil, China	1,3	3,12	2,40
Sierozem, China	0,3	0,72	2,40

[a] calculations accurate to two decimal places

Note: Comma represents decimal point.

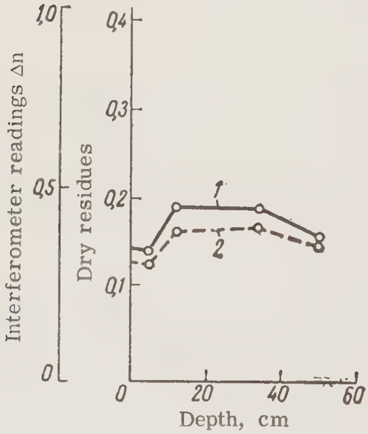


Fig. 2. - Calibration curve for determining dry residue in a Chinese soil.

1 - dry residue; 2 - interferometer readings

solution being analyzed may be so high that there are insufficient divisions on the scale of the compensator. In this case one must either take a shorter cell or construct a new calibration curve, using a solution with a known concentration of the salt as a calibration curve, using a solution with a known concentration of the salt as a calibration standard. In all other respects the procedure is the same as before.

Determination of Dry Residues in Water Extracts from Soils. The determination of dry residues in water extracts is based on the fact that different substances alter the refractive index of water by very similar amounts when their content in the solution is the same. It therefore follows that d = Δ n/dry residue is practically a constant.

There is no information in the literature on determination of the most likely value for d. Over 20 different soils from the light-chestnut and brown soil zones of the arid southeast, as well as some samples received from China, were investigated in our determination of d.

There were considerable differences in the texture and morphological features of the soil samples. They were all saline to some extent and contained considerable amounts of water-soluble compounds.

Water extracts of these soils were prepared in the usual way. Dry residues in the extracts were determined (gravimetrically). The interferometer cell was simultaneously filled with water extract and with the distilled water used to prepare the extract, in order to determine Δn, the difference between the refractive index of the water and the water extract. In all we determined some 400 values of Δn and found the

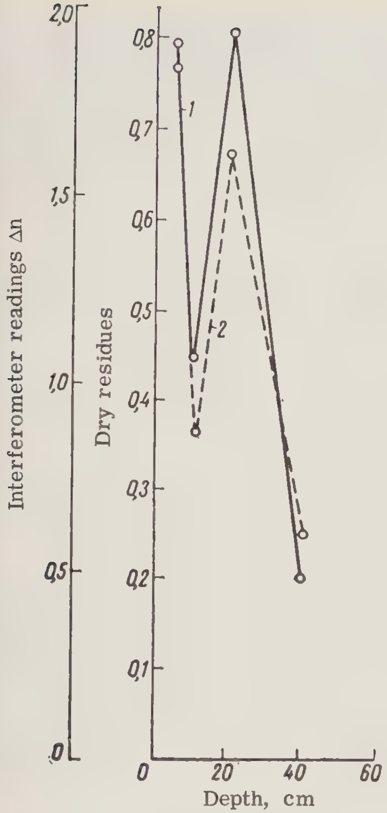


Fig. 3. - Calibration curve for determining dry residues in a solonchak (mouth of the Lena).

1 - dry residue; 2 - interferometer readings

ivalent value for the dry residue in each e. Some of the values are given in Table 1.

Table 1 shows that d was almost the same, pproximately 2.4, in all the soils studied.

Both the numerical value of d and the nature ts stability and the extent of its reliability be seen from the graphs in Figures 2 and 3. hese graphs the numerical values of Δn and dry residues are plotted along the y-axis. corresponding depths (η) (the points in the profile from which the samples were taken) plotted along the x-axis. Each graph, there-, has two types of curve

$$\Delta n = f'(\eta)$$

$$\text{dry residue} = f(\eta)$$

re η is the depth in cm from which the ple was taken.

A striking feature of these curves is their l geometric similarity. This is extremely ortant since it shows that these phenomena dependent on factors for which intercorrela- is quite simple. One can easily interpret the relevant data since the correlation factor is a constant.

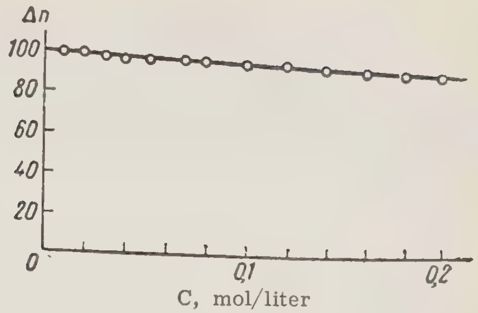


Fig. 4. - Calibration curve for determining D_2O; $n = f(C)$ at a temperature of 17±1° C.

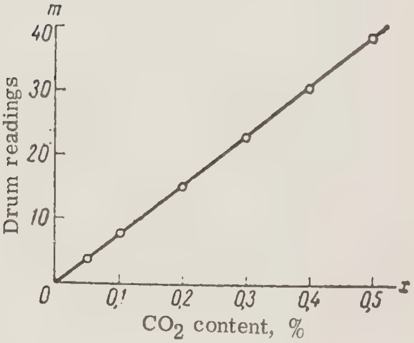


Fig. 5. - Calibration curve for determining CO_2 in air, $m = f(x)$

It is, in fact, sufficient when determining the dry residue to fill one cell of the interferometer with the standard liquid and the other with the water extract and read off Δn from the drum. The amount of dry residue as a percentage can then be found by dividing Δn by 2.4.

The whole procedure takes 1-2 ml of solution and is completed in a few minutes.

Determination of Heavy Water. More and more use is now being made of various forms of heavy water in biological research. When determining the proportion of heavy and light hydrogen and oxygen isotopes in isotopic analysis, one half of the cell is filled with a standard sample (pure water) and the other with the solution of D_2O^{16} or H_2O^{18} in ordinary water. The difference Δn between the refractive indices of the sample and the standard is approximately proportional to the D_2O^{16} (or H_2O^{18}) concentration. If the numerical value of the concentration is denoted by C, then

$$\Delta n = KC,$$

where K is the proportionality factor.

This relationship can be used to determine the deuterium. A series of samples with a known content of D are prepared (the concentrations of D_2O^{16} are normally selected so as to form an increasing series). The value of Δn on the scale of the drum is found for each sample. This gives us the assigned concentrations of D_2O in mol/liter and the experimentally determined values for the refractive indices (Δn). We arrange these values as ascending series:

C mol/liter (x)	0,01	0,02	0,03	0,04	0,05	0,06	0,07	0,08	0,09	0,1	1,12	0,14	0,16	0,18	0,20
Drum records (Δn)	99,5	98,5	98,0	98,0	97,5	97,0	98,0	97,0	—	94.5	94,0	93,5	92,0	90,5	90,0

The calibration curve Δn = f (c) given in Figure 4 is constructed from these values.

Examination of the curve shows that there is a linear relationship between the variables Δn and C and that the angle of slope is approximately 87°. Thus, the concentration C mol/liter of the solution being studied can be found easily from the calibration curve if Δn is determined experimentally. If the concentration C is so high that there are not enough divisions on the compensator scale, a new curve is constructed with a solution with a known concentration of D_2O as the standard instead of the pure solvent, or a shorter cell is selected. The name of the system, the cell No. and the temperature at which calibration was conducted are recorded on the calibration curve.

Analysis of Gases

The interferometer can be used extensively in gas analysis. The investigation of gas mixtures is based on the known law of Biot—Arago, according to which partial refractive forces are additive in a gas mixture.

If x, y, z, etc., are the percentage content of the components, and $\beta_1, \beta_2, \beta_3 \ldots$ are the corresponding strengths of these components, the refractive power of the mixture will be

$$\beta = \frac{x\beta_1}{100} + \frac{y\beta_2}{100} + \frac{z\beta_3}{100}$$

For a binary system such as a mixture of CO_2 and air freed of carbon dioxide

$$\beta = \frac{x\beta_1}{100} + \frac{(100 - x)\beta_2}{100}$$

where β, as in the previous case, is the refractive index of the mixture, β_1 is the refractive index of the gas under investigation (CO_2), β_2 is the refractive index of the standard (air),[3] x is the percentage content of the gas being tested.

The refractive indices of pure gases are known from the literature (see, for example, Eyken's tables [2]), and one therefore only need know

$$\frac{x}{100} \text{ and } \frac{100 - x}{100}.$$

to be able to determine β by equation (3).

We shall consider cases in which the percentage concentration of CO_2 in a carbon dioxide-air mixture is x = 0.05%, 0.1%, 0.2%, 0.3%, 0.4%, and 0.5%.

From the tables in Eyken (2) we find $\beta_1 = 450$, $\beta_2 = 293$. It is a simple matter to calculate by substituting the numerical values of β_1, β_2, and x in equation (3). Values for β found in this way are given in Table 2.

It should be noted that there is a linear relationship between the difference of the refractive indices of the gases Δn and the number of scale divisions m, i.e.,

$$\Delta n = n - n_2 = f(m)$$

Reasoning in a similar manner and using the same notations as in equation (3), we can write

$$\Delta\beta = \beta - \beta_2 = f(m) \text{ and}$$
$$x = f'(m)$$

Numerical values of $\Delta\beta$ found from equation (4) are given in Table 2. The values in this table were used in the construction of the calibration curve x = f(m), shown in Figure 5.

Determination of CO_2 in Air

Using the curve (Fig. 5) we systematically determined the CO_2 content of the air (in the laboratory). One chamber of the gas cell (1 = 100 cm) was filled with air freed of carbon dioxide (standard),[4] and the other with the air in

---

[1] The limits within which the Biot—Arago law is applicable still have not been conclusively established. Empirical curves are, therefore, often used in practice in addition to theoretically derived calibration curves. We used both methods.

[2] Air freed of carbon dioxide is a multi-component system, which is, however, treated as a single-component system since its composition does not vary during the measurements.

[3] Ordinary air freed of CO_2 or nitrogen are used as standards.

[4] An aspirator was used to fill the chamber. Sodium carbonate mixed with lime is used as the CO_2 absorbent Pressure in the series of measurements fluctuated by 2-3 mm of mercury.

Table 2

Calculation of data for constructing the curve $(x) = f'(m)$

CO_2 content in air in percentages by weight (x)	Determination of $\beta = \frac{x\beta_1}{100} + \frac{(100-x)\cdot\beta_2}{100}$	Determination of $\Delta\beta$ $\Delta\beta = \beta - \beta_2$	Determination of m (number of divisions on the drum)[b]
$x_1 = 0,05$	$\beta = \frac{0,05\cdot 450}{100} + \frac{99,95\cdot 293}{100} = 293,07$	$\beta\Delta = 293,07 - 293 = 0,07$	$m = \frac{0,07}{0,02} = 3,5$
$x_2 = 0,1$	$\beta = \frac{0,1\cdot 450}{100} + \frac{99,9\cdot 293}{100} = 293,16$	$\beta\Delta = 293,16 - 293 = 0,16$	$m = \frac{0,16}{0,02} = 8,0$
$x_3 = 0,2$	$\beta = \frac{0,2\cdot 450}{100} + \frac{99,8\cdot 293}{100} = 293,31$	$\Delta\beta = 293,31 - 293 = 0,31$	$m = \frac{0,31}{0,02} = 15,5$
$x_4 = 0,3$	$\beta = \frac{0,3\cdot 450}{100} + \frac{99,7\cdot 293}{100} = 293,47$	$\Delta\beta = 293,47 - 293 = 0,47$	$m = \frac{0,47}{0,02} = 23,5$
$x_5 = 0,4$	$\beta = \frac{0,4\cdot 450}{100} + \frac{99,6\cdot 293}{100} = 293,62$	$\Delta\beta = 293,62 - 293 = 0,62$	$m = \frac{0,62}{0,02} = 31$
$x_6 = 0,5$	$\beta = \frac{0,5\cdot 450}{100} + \frac{99,5\cdot 293}{100} = 293,78$	$\Delta\beta = 293,78 - 293 = 0,78$	$m = \frac{0,78}{0,02} = 39$

---

[a] Numerical values of β_1 and β_2 taken from Eiken's tables (2).

[b] The magnitude of m was determined by calculation (1 drum division is equivalent to 0.02β for a cell 1 = 100 cm).

Note: Comma represents decimal point.

Table 3

Data for CO_2 determination in laboratory air in January

Date of determination	6	8	13	15	20	25	27
Drum readings (m)	9	1,5	5,5	8	10	7,5	14
Percentage content of CO_2 [a]	0,11	0,04	0,07	0,10	0,13	0,10	0,24

[a] The increased CO_2 content noted on January 6, 20 and 27 was due to the use of dry ice in the laboratory on these dates.

Note: Comma represents decimal point.

e room (by natural gas exchange with the sur-unding atmosphere). The first chamber was oppered (to exclude contact with the environ-ent), while the other remained open. After uilibrium had been reached, the number of visions on the drum was read off. The per-ntage content of CO_2 was found (Table 3) from e value of m, by using the calibration curve.

Determination of Humidity of the Air

The interferometer can be used to check the ter vapor content of the air. Procedure is e same as in the previous case. One chamber filled with air from which water vapor has en removed (standard), and the other with the air being tested. The percentage content of CO_2 in the air can be found by using the calibration curve.[5]

Possible Applications

The interferometer also can be used for other purposes. It appears from the literature that it can be used to prepare and compare titration standards (1), and to determine and study dry residues in waters of various origin (3). The interferometer is a very convenient instrument for determining total salinity of water under field conditions, for determining the quality of piped water (4), for the determination of colloidal suspensions, and for the analysis and study of other systems.

---

[5] Calibration curve obtained by the same method as has been described previously.

By analogy with the technique used in analyzing mine gases, the interferometer can be used to study soil air and to analyze gases evolved in the fermentation of organic matter in composts and dung-pits, as well as to study other subjects of interest to soil scientists and agricultural chemists.

Conclusions

The basic principles of interferometric analysis are discussed.

The possible scope for the use of interferometry in soil and agricultural chemical research is examined.

The principles of interferometry are shown to be extremely effective in the analysis of soil solutions, gas mixtures, and moisture in vapor form, as well as in the determination of dry residues and the hardness of water.

Received August 18, 1959

BIBLIOGRAPHY

1. BRODSKIY, A.I. 1936. Analysis by interferometry. Zavodskaya literatura, Vol. 8.
2. EYKEN, A. 1936. Industrial physicochemical analysis. Leningrad.
3. BERL, E., and G. RANIS. 1927. Fortschr. Chem. Physik und phys. Chem., No. 19. (In German).
4. MARC, K., and K. SACK. 1914. Kolloid-Beihefte, No. 5. (In German).

CHRONICLE

LADIMIR PETROVICH BUSHINSKIY

group of colleagues

Professor Vladimir Petrovich Bushinskiy ed on April 22, 1960 in his 76th year. Profes- r Bushinskiy, who was a Doctor of Agricul- re, was one of our leading scholars in soil ience and agriculture. He held the title of nored Worker in Science and Technology, and s a full member of the Lenin Academy of ricultural Sciences and a corresponding mem- r of the USSR Academy of Sciences. He was e head of the soil science faculty in the miryazev Agricultural Academy in Moscow.

Bushinskiy, the son of a bank employee, was rn on March 14, 1885 in Yekaterinoslav. He ceived his secondary education at the techni- l high school. In 1911 he graduated with nors from the Moscow Agricultural Institute ow the Timiryazev Agricultural Academy) and mained at the request of Professor Vil'yams prepare for scientific work and teaching.

Bushinskiy began research in 1906 when he s still a student. He cooperated closely with R. Vil'yams for more than 30 years and was s closest pupil, continuing Vil'yams teaching. a mark of true friendship, and in recognition his services as a scholar, Vil'yams dedicated e special chapter in his book "Soil Science" titled "The development of the initial process soil formation," to Bushinskiy. In this chap- r he deals with theoretical aspects of soil ience and the natural sciences.

In an early published work (1914) devoted to e 25th anniversary of Vil'yams work as a ientist, teacher, and public figure, Bushinskiy ote that farming practices are concerned in e main with the soil. He followed his teacher repeatedly stressing that the development, construction, and intensification of socialist riculture would make "questions concerned h an understanding of soils of overriding im- rtance...." (Soils of the Stalingrad Guberni- 1929, p. 14).

Bushinskiy's numerous works (he published 5) were a development of the main features Academician Vil'yams' teaching, and a great ntribution to the development of soil science l agriculture. He edited the 12 volumes of 'yams' Collected Works. His research work s many-sided. He took part in and led many peditions in various districts, and organized l directed all types of laboratory and field tion research on soils, especially in the arid steppe and desert. As long ago as 1906-1909 Bushinskiy discovered the reason for the formation of diversity in soils, when studying areas then known as the Chern, Yefremov, and Bogorod uyezds of the Tula Guberniya. This discovery was of great theoretical significance at the time. A little later he made special studies to reveal the effect of trees on the degree and nature of podzolization. At this stage Bushinskiy was stressing the role of biological and biochemical processes in the development of soils.

When he published "An outline theory of the soil based on Vasiliy Robertovich Vil'yams' views" in 1914, Bushinskiy did not restrict himself to an exposition of Vilyams' outlook, but also gave his own view on some of the fundamental aspects of soil science, which he treated consistently from an agricultural biological standpoint.

In his work "Soils of the Stalingrad Guberniya" (1929), Bushinskiy advanced an original outline of soil-forming processes and the corresponding genetic soil groups for meadow, arid, and desert steppes, based on "...Dokuchayev's laws, as developed in detail by Professor Sibirtsev, and on Professor Vil'yams' conclusions concerning the role of biological factors in the processes of soil formation." Some of his propositions, such as the subdivision of chestnut soils into three subgroups (dark chestnut, chestnut, and light chestnut) and the distinguishing of brown soils in the desert steppe have been firmly incorporated in the literature of the subject.

His studies of the solonetzization and "salinization" of soils of the arid steppe, of the conduct of dry and irrigated farming, and of the improvement and treatment of solonetzic and saline soils, have not lost their scientific and practical significance to this day.

In 1948-1950, a group from the faculty headed by Bushinskiy undertook large-scale studies of the soils along the State forest belts. The virgin soils of Northern Kazakhstan were the subject of detailed study from 1954 on, and in 1957 Bushinskiy organized a detailed investigation of the soils of the Arkhangel' Oblast'.

Bushinskiy worked for more than 20 years on aspects of the theoretical basis for deepening the plowing horizon and extending the depth to which sod-podzolic soils are cultivated. When he started to study this problem he wrote that "the present stage in socialist agriculture urgently demands the creation of cultivated soils and of all the conditions for continuous increase in their fertility" (In: In Memory of Academician V.R. Vil'yams, p. 43). Bushinskiy did experimental work on this question in a special experiment field, which he set up in 1943-1944 on the teaching and experimental farm of the Shchapovo Academy in the Moscow Oblast'.

In addition to being a great scholar, Bushinskiy was a good organizer and a tireless public figure. Between 1922 and 1951 he headed a number of scientific research establishments of national importance (The All-Union Institute of Agricultural Soil Science, The Institute for the Study of Saline and Irrigated Soils, The Soil Biology Laboratory of the USSR Academy of Sciences, etc.). He was a board member of the Chief Administration of Professional Training of the Peoples' Commissariat of Public Education, a member of the Presidium of the Lenin All-Union Academy, Chairman of the commission of experts of the Higher Education Course of the Ministry of Higher Education, a member of Gosplan of the USSR, a member of many scientific and technical associations, and a member of the Presidium of the Central Committee of the Union of High School Employees. He was a member of the Editorial Board of Pochvovedeniye for many years.

The Soviet government had a high opinion of Bushinskiy's activity as a scientist, teacher and public figure. He received six Orders and many medals.

We shall always remember Vladimir Petrovich Bushinskiy.

YEVGENIY PETROVICH TROITSKIY

Soil Department of the Biological and Soil Faculty of Moscow State University

Yevgeniy Petrovich Troitskiy, Doctor of Geology, and a senior professor in the soil science faculty of the Moscow State University, died on June 22, 1960.

Soviet soil science has lost an outstanding teacher, one who instructed many of the Soviet Union's soil scientists, and a soil chemist of wide erudition.

Troitskiy devoted 45 years of his life to teaching and developing chemical analysis and soil chemistry in Moscow University. The Party and Government showed great regard for Professor Troitskiy's many years of fruitful activity when they awarded him the Order of Lenin.

Troitskiy was born on February 22, 1890 in Tsaritsyn (now Stalingrad). He received his higher education in the Petersburg Teaching Academy and Moscow University, from which he graduated in 1915 in agricultural chemistry and soil science. After finishing his course he remained in the agricultural chemical faculty to prepare for a professorship, but in a supernumerary capacity as an assistant.

For many years Troitskiy was the head of the soil and analytical chemistry laboratory of the soil science research institute of Moscow University. In 1941 he publically defended his doctorate thesis for the degree of Doctor of Geology and Mineralogy on the subject: "The chemical foundations of the process of humification," and in 1943, he became a professor. From this time until the end of his life Troitskiy headed the faculty of soil chemistry and analysis, and then the laboratory of the same name in the soil science faculty of Moscow University. Apart from his great teaching activity, he also undertook a considerable amount of organizational and public work.

His first scientific work was a dissertation on "The chemical nature of the humic acids of a chernozem from selective oxidation figures" (1915-1917). He was the first person to isolate and identify terephthalic acid in the oxidation products of the humic acids of a Samara chernozem. It was on this work that he based the furan theory to account for the structure of the humic acid nucleus, and his method of fractional oxidation is successfully employed by contemporary students of soil organic matter. He continued to study humus all his life. In his later years he concerned himself with the structure of humic acids and paid particular attention to the part played by nitrogen in the formation and structure of humic matter.

Troitskiy was one of the first in the Soviet Union to stress the importance of microelements in soil science. He directed research on the microelement content of vitaminic plants (1943-1946), investigation of microelements in the system: soil—grapevine—grape—wine (1946-1949) and other subjects. In these studies Troitskiy drew attention to the importance of microelements and, in particular, to their part in the biochemical processes of soils, and especially in the synthesis of humic matter. In recent years Troitskiy had been developing the principles of a theory of microelements and their role in soil processes. For several years he had delivered a course of lectures entitled "The theory of microelements" to soil science students in the biology and soil faculty of Moscow State University. The textbook which he wrote is now at press.

Troitskiy was a widely educated analytical chemist of great erudition. For many years he lectured and directed practical work on quantitative and qualitative analysis in the chemical faculty of Moscow University, while simultaneously acting as director of courses on the silicate (faculty of soil geology) and chemical analysis of soils (soil department). He directed work on the analytical chemical description of soils from various districts, regions, and Republics in the USSR, and on the analysis of soil samples collected by the detachments of the Don expedition, and by many other expeditions, including those to the Middle and Lower Volga and to the Solikamsk irrigation project.

Troitskiy worked out the first original Soviet soil chemistry course, which he began to deliver to students and postgraduates in the soil department in 1935.

Troitskiy was a fine lecturer who understood and knew his audience: his exposition of the most intricate aspects of contemporary chemistry and soil chemistry was clear and graphic. A teacher by vocation, he knew how to arouse an interest in science and how to frame and conduct scientific studies in an original manner. He supervised the work of postgraduates and many of his students are now lecturers and professors.

Troitskiy was a simple, warm-hearted man who was always ready to help a colleague or anyone who turned to him for advice and information.

His many pupils and colleagues will long remember Yevgeniy Petrovich Troitskiy.

ALEKSEY ALEKSANDROVICH STOL'GANE

A group of colleagues

Professor Aleksey Aleksandrovich Stol'gane, one of our oldest agricultural chemists and an outstanding educator, died in Zhitomir on March 14, 1960 in his 77th year.

He was born in 1884 at Torzhok in the Kalinin Oblast'. In 1904 he finished his course at the Pskov Technical High School and entered the Moscow Agricultural Institute (now the Timiryazev Agricultural Academy), where his first scientific work in D. N. Pryanishnikov's laboratory was concerned with the plant availability of potassium silicates.

On completing his course at the Institute in 1910, Stol'gane remained in the organic chemistry faculty, where he conducted useful scientific work on organic synthesis under the direction of N. Ya. Dem'yanov, while holding the position of assistant and, from 1921 onwards, lecturer in the agricultural analysis course. At the same time he accepted Ya. V. Samoilov's invitation to act as consultant agronomist to the Committee for Fertilizers and subsequently to the Fertilizer Research Institute (NIU), where he helped to establish the Dolgoprudnyy experimental field and became its first director. A number of his original papers on plant uptake of cations and anions, the effect of the osmotic pressure of a nutrient medium on a plant, and comparison of various nutrient media appeared in the Bulletin (Izvestiya) of the Moscow Agricultural Institute. Popular pamphlets by Stol'gane on soil liming and the use of bone meal, ashes, and other local fertilizers were published by the Fertilizer Research Institute.

Stol'gane joined V. R. Vil'yams in organizing the Workers' Faculty of the Timiryazev Agricultural Academy and was its Dean in 1921-1922. His articles on the organization of the Workers' Faculty and the training of a new force of highly qualified agronomists were published in "Novaya Petrovka."

Stol'gane's selection as a professor in the faculty of general agriculture and agrochemistry in the Omsk Agricultural Institute was the beginning of a new period in his academic life and public work. During the 20 years in which he worked at Omsk (with a brief intermission in 1930-1933, when he worked at the Tashkent and Kuybyshev Institutes) Stol'gane set up a greenhouse and organized an experiment field and research and teaching laboratories in the faculty. He taught his own course of general agriculture and was prominent in the organization of experimental work in Western Siberia. He wrote our first textbook on "Agronomic analysis" (1926). Whole generations of Soviet agronomists were trained from this book. Stol'gane studied the response of West Siberian soils to fertilizers and the effect on yields of cultivating the root layer of the soil. He devised a system for working early fallow sown to winter wheat, in which the main plowing was shifted from spring to autumn. He published papers on these subjects in the Proceedings (Trudy) of the Omsk Agricultural Institute and in Pochvovedeniye. He published a guide to field crop cultivation and works on the procedure to be followed in field experiments. His wide learning and knowledge of practical agriculture enabled Stol'gane to compile his "Course of farming practice in Western Siberia" and to show the harmful consequences of thoughtless introduction of the grassland system of farming into Western Siberia.

In 1948, Stol'gane moved to the Zhitomir Agricultural Institute where he headed the chemical faculty until his death. Here he wrote a textbook of organic chemistry for the agronomy faculties of agricultural institutes.

Stol'gane taught and trained thousands of agronomists who now work in all corners of the Soviet Union, especially in Siberia.

Stol'gane was a cheerful and fascinating man of rare wit, who adopted a most principled attitude to the defense of his viewpoints. Personal contact with him always left its mark, and his new ideas and creative suggestions always fired his listeners with optimism and belief in the great transforming power of science.

It is usually thought that a scholar's life is to be found in his works. Stol'gane is dead, but his interesting works will remain a significant contribution to agronomy for years to come, and will help to train agronomists and advance socialist agriculture.

His many pupils and colleagues will always preserve the memory of Stol'gane as an indefatigable scholar and teacher, who was a modest and fascinating man and a fine instructor.

BIBLIOGRAPHY

SOIL FORMATION FACTORS, GENESIS, AND GEOGRAPHY OF SOILS

Agricultural climatic handbooks: Vinitskaya Oblast'. 1959. Gossel'khozizdat Ukr SSR, Kiev, 95 pp.; Irkutsk Oblast', 1959, Gidrometeoizdat, Leningrad, 158 pp., illust., 4 maps. Bibliog. 36 refs.; Kemerov Oblast', 1959, Gidrometeoizdat, Leningrad, 139 pp., illustr., 2 maps; Kiev Oblast', 1959, Gossel'khozizdat UkrSSR, 134 pp., illustr., 2 maps, (In Ukrainian); Krymskaya Oblast', 1959, Gidrometeoizdat, Leningrad, 136 pp., map. Bibliog. 22 refs.; Latvian SSR, 1959, Riga, 138 pp., 6 maps. Bibliog. 47 refs. (In Latvian); Lithuanian SSR, 1959, Gospolitnauchizdat, Vil'nius, 138 pp., illustr., maps, (In Lithuanian and Russian); Perm Oblast', 1959, Gidrometeoizdat, Moscow, 132 pp., illustr., 3 maps; Pskov Oblast', 1959, Gidrometeoizdat, Moscow, 139 pp., illustr., 2 maps; Stanislav Oblast', 1959, Gossel'khozizdat, Kiev, 99 pp., 2 maps, (In Ukrainian); Tadzhik SSR, 1959, Gidrometeoizdat, Leningrad, 152 pp., illustr., 2 maps; Ternopol Oblast', 1959, Gosselkhozizdat UkrSSR, Kiev, 95 pp., 2 maps, (In Ukrainian); Khel'nitskiy Oblast', 1959, Gossel'khozizdat UkrSSR, Kiev, 83 pp., 2 maps, (In Ukrainian); Cherkass Oblast', 1959, Gossel'khozizdat UkrSSR, Kiev, 99 pp., 2 maps. Bibliog. 24 refs., (In Ukrainian).

ANTROPOVA, N. A. 1959. Agrocultural climatic conditions of the Tatar ASSR. Kazan, Tatknigoizdat. 204 pp., Bibliog. pp. 149-150.

BLAGOVIDOV, N. L. 1960. Qualitative evaluation of land (Site quality of soils and land evaluation). Moscow. Izd. M-vo s.-kh. RSFSR, 79 pp., tables. Bibliog. 48 refs.

BIKMUKHAMEDOV, M. A. 1960. Grey-brown soils of the Kzyl-Ordinsk Oblast'. Izv. Akad. Nauk KazSSR, Ser. bot. i pochvoved., 2:3-7. Bibliog. p. 7. (Summary in Kazakh).

BOGDANOV, G. YA. 1960. Regional division of the northwestern area of the Precaspian lowland in the Stalingrad Transvolga by types of hydrochemical regime. Izv. VUZ, Geol. i raz., 3:109-115, map. Bibliog. 6 refs.

6. VERNANDER, N. B., S. A. SKORINA, and A. S. SKORODUMOV. 1959. Land resources of the Ukraine, evaluation and calculation procedure. (Mat. k 3 s''yezdu Geogr. o-va SSSR). Leningrad, 16 pp. (Duplicated document).

7. VLADYCHENSKIY, S. A. 1960. The effect of excess moisture on soil of the coasts of the Rybin reservoir. Nauchn. dokl. vyssh. shkoly. Biol. nauki, 2:191-197. Bibliog. 5 refs.

8. VOZNYUK, S. T. 1959. Peat bog soils of the left bank of the middle Dnieper region: genesis, classification, and productive features (Based on the Trubezh catch basin). Author's summary of Doctorate thesis. Dokuchayev Agric. Inst., Khar'kov, 22 pp.

9. VOLKOVA, V. P. 1959. A description of the solonetzic soils of the Kura-Araks lowland. Author's summary of Candidature thesis. Dokuchayev Soil Inst. Acad. Sci. USSR. Novocherkassk, 16 pp.

10. GVOZDETSKIY, N. A. 1959. Physicogeographic regionalization of the USSR for agricultural purposes. (Mat. k 3 s''yezdu Geogr. o-va SSSR). Leningrad, 30 pp. (Duplicated document).

11. RIKHTER, G. D. (Edit.). The geography of snow. 1960. Moscow. Izd. Akad. Nauk SSSR, 222 pp., illustr., map. Bibliog. for 1955-1958.

12. GERASIMOV, I. P. 1959. Hydrothermal factors of soil formation. (Mat. k 3 s"yezdu Geogr. o-va SSSR). Leningrad, 15 pp., 1 table. (Duplicated document).

13. DZHANASHIYA, A. A. and G. M. OGANOV. 1960. Soil and climatic conditions of the Lenkoran zone and the prospects of tea cultivation. Subtrop. kul'tury, No. 1:39-42. Bibliog. p. 42.

14. DIMO, N. A. and R. I. LUNEVA. 1960. Compact chernozems of Central Moldavia. Tr. Pochv. in-ta Mold. f-la Akad. Nauk SSSR, No. 4:19-36. Summary in Moldavian. Bibliog. 39 refs.

15. YEGOROV, V. V. 1960. Soil formation and the conditions for reclamation irrigation in the deltas of the Aral-Caspian lowland.

Author's summary of Doctorate thesis (Moscow Univ., Biol. faculty). Moscow, 38 pp. Bibliog. 17 refs.

16. ZONN, S. V. 1959. In the tropics of Southern China. Moscow, Geografgiz, 160 pp., illustr.

17. KALESNIK, S. V. 1959. The contemporary state of landscape theory. (Mat. k 3 s"yezdu Geogr. o-va SSSR), Leningrad, 17 pp. (Duplicated document).

18. KARNAUKOV, N. I. 1959. Spruce forest soils of the middle Angara region in the Ust'-Udinsk district of the Irkutsk region. Izv. Sib. otd. Akad. Nauk SSSR, No. 8: 107-112. Bibliog. 9 refs.

19. KENESARIN, N. A. 1959. The formation of a ground-water regime in irrigated districts from the example of the Hungry Steppe. Tashkent. Izd. Akad. Nauk Uz-SSR, 179 pp., illustr. Bibliog. 217 refs.

20. KIM, F. N. 1959. Flooding regime of flood plain estuaries in the semidesert zone of Western Kazakhstan. Author's summary of Candidature thesis (Kazakh Agric. Acad. Water Inst.). Alma-Ata, 20 pp.

21. KOGOTKOV, A. YA. 1960. Soils of the Kotlas region of the Arkhangel'sk region, and some features of their oxygen regime. Author's summary of Candidature thesis (Moscow Timiryazev Agric. Academy). Moscow, 22 pp.

22. KOLYAGO, S. A. 1959. The genetic nature of the "brown forest" soils of Siberia. Izv. Sib. otd. Akad. Nauk SSSR, No. 8: 113-114.

23. A short agricultural climatic handbook of the Azerbaydzhanian SSR. Leningrad, Gidrometeoizdat, 1959. 68 pp. map.

24. KRUPENIKOV, I. A. and A. K. RODINA. 1960. Soils of the Kagul rayon of the Moldavian SSR (brief sketch). Tr. Pochv. in-ta Mold. f-la Akad. Nauk SSSR, No. 4: 57-72, map. Bibliog. 18 refs. Summaries in Moldavian.

25. KRUPENIKOV, I. A. and A. F. URSU. 1960. Agricultural productive grouping of the soils of Southern Moldavia. Op. cit., 47-55. Bibliog. 18 refs. Summaries in Moldavian.

26. KRUPKIN, P. I. 1960. Features of the steppe and forest-steppe solonetzes of the Omsk Oblast' and aspects of the genesis of solonetzic soils. Author's summary of Candidature thesis (Kazan State Univ.). Kazan, 21 pp.

27. LAVROV, A. P. and F. F. TRAPEZNIKOV. 1959. Soils of reclaimed regions around the Kara-Kum canal. Ashkhabad. Turkmengosizdat, 45 pp. (In Turkmenian).

28. LIVEROVSKIY, YU. A. 1959. Plain soils of the Kamchatka peninsula. Moscow. Izd. Akad. Nauk SSSR, 130 pp., illustr., map. Bibliog. pp. 126-129.

29. LUNEVA, R. I. 1960. Soils of the Dussobar rayon of the Moldavian SSR. Tr. Pochv. in-ta Mold. f-la Akad. Nauk SSSR, No. 4: 73-83, map. Bibliog. 14 refs. Summary in Moldavian.

30. MATYSHUK, I. V. 1960. Description of the light chestnut soils of an experiment field on the Karaganda agricultural experiment station. Izv. Akad. Nauk KazSSR, Ser. botan. i pochvoved., No. 2:71-96. Bibliog. pp. 94-96. Summary in Kazakh.

31. MINERVIN, A. V. 1959. Genesis and engineering geological description of the mantle deposits of the Ob valley (middle and lower reaches). Author's summary of Candidature thesis (Moscow State Univ., Soil and Eng. Geol. Faculty). Moscow, 23 pp.

32. NIKITIN, S. A. 1960. The classification of semidesert vegetation. Vopr. geogr., No. 48:194-204, map. Bibliog. pp. 203-204.

33. NOMOKONOV, L. I. 1959. Flood plain meadows of the Yenisey. Izd. Akad. Nauk SSSR (Sib. otd.) 456 pp., illustr. Bibliog. pp. 350-356.

34. PEREL'MAN, A. I. 1959. The migration of salts on the plains of Eastern Turkmenia and Western Uzbekistan in the Neogene. The ancient soils of the Central Asian deserts. Tr. In-ta geol. rudn. mestorozhd. petrogr., mineral. i geokhimii, No. 25:1-110, illustr. Bibliog. pp. 105-109.

35. LETUNOV, P. L. et al. 1959. Soil-bioclimatic regionalization of the USSR. (Mat. k 3 s"yezdu Geogr. o-va SSSR). Leningrad, 30 pp., 1 table. (Duplicated document).

36. REYTMAN, L. YU. 1960. Soils of Southeastern Estonia. Author's summary of Candidature thesis (Eston. Agric. Acad.). Tartu, 44 pp., map.

37. REMEZOV, N. P., L. N. BYKOVA, and K. M. SMIRNOVA. 1959. Nitrogen requirement and cycle in ash elements in the forests of European Russia. Izd. Mosk. un-ta, 284 pp., illustr., Bibliog. pp. 281-283.

38. URYVAYEV, V. A. (General Editor). 1959. Surface water resources in rayons where virgin and abandoned lands are being brought into cultivation. Tr. Gos. gidrol. in-ta, No. 4:1-576, illustr., map. Bibliog. 147 refs.

39. RUMYANTSEVA, A. YA. 1960. The soil of the Oredezh basin. Uch. zap. Len. ped. in-ta im. Gertsena, No. 205:127-148. Bibliog. 7 refs.

40. SEVAST'YANOV, N. F. 1959. Soils of the North Crimean lowland and their agricultural utilization. Author's summary of Candidature thesis. (Ukr. Agric. Acad., Ukr. Soil Science Res. Inst.). Khar'kov. 20 pp.

BIBLIOGRAPHY

SEDENKO, M. V. 1960. Physico-mechanical properties of the loess-like clay loams of the Dnieper basin lignite deposits. Izv. VUZ. Geol. i razvedka, No. 3:116-118.

SELIVANOV, A. P. 1959. Soils of the Amur region. Blagoveshchensk, Amursk. kn. izd., 182 pp., illustr. Bibliog. 170 refs.

SEMENOVA, N. N. 1960. Aerial photography in studying and mapping the soils of the steppe and arid steppe. Author's summary of Candidature thesis (Leningrad State Teaching Inst.). Leningrad, 15 pp.

RODE, A. A. (Gen. Editor). 1959. Contemporary soil processes in the forest zone of European Russia. Izd. Akad. Nauk SSSR (Dokuchayev Soil Inst.), 220 pp., illustr.

SOKOLOV, A. A., R. DZHANPEISOV, and K. SH. FAIZOV. 1960. Systematics of the Irtysh region chestnut soils. Izv. Akad. Nauk KazSSR, Ser. botan. i pochvoved., No. 2:36-45, map. Bibliog. pp. 44-45. Summary in Kazakh.

SOKOLOVSKIY, I. L. 1960. Loess parent materials in the west of the Ukr. SSR. Author's summary of Doctorate thesis (Acad. Sci. Ukr. SSR, Inst. of Geology). Kiev, 31 pp. Bibliog. 22 refs.

SOLOV'YEV, P. YE. 1960. The influence of field shelter belts and forest blocks on the soil-forming process and fertility of steppe soils. Author's summary of Candidature thesis (Moscow Univ.). Moscow. 31 pp.

TEMNIKOVA, N. S. 1959. The climate of the North Caucasus and the adjacent steppes. Gidrometeoizdat, 368 pp., illustr., map. Bibliog. 278 refs.

TOLSTOUSOV, V. P. 1960. Soils of the Yelan'-Kolena State Beet Farm in the Voronezh region, genesis, properties and increasing fertility. Author's summary of Candidature thesis (Voronezh Agric. Inst.). Voronezh, 22 pp.

TUPOTILOVA, A. N. 1960. Climatic study of the Udmurt ASSR. Uch. zap. Len. ped. in-ta im. Gertsena, No. 205:97-125. Bibliog. 13 refs.

TYUTYUNOV, I. A. 1960. The processes of the alteration and transformation of soils and rocks by negative temperature (cryogenesis). Izd. Akad. Nauk SSSR, Inst. merzlotoved. 144 pp., illustr. Bibliog. pp. 136-142.

URSU, A. F. and A. M. KHOLMETSKIY. 1960. Saline soils of the Kogil'nik flood plain. Tr. Pochv. in-ta Mold. f-la Akad. Nauk SSSR, No. 4:37-45. Bibliog. 14 refs. Summary in Moldavian.

FEDOROVICH, B. A. 1960. Aspects of the origin of loess, in relation to the conditions of its distribution in Eurasia. Tr. In-ta geogr. Akad. Nauk SSSR, Vol. 80, pp. 96-117. Bibliog. pp. 116-117.

54. CHKIKVISHVILI, V. I. 1960. Saline soils of Georgia and their agricultural utilization. Tbilisi, "Sabchota Sakartv", 117 pp., illustr., map. Bibliog. 57 refs.

55. HILLS, G. A. 1960. Soils of the Canadian Shield. Agric. Inst. Rev. Canada (15)2: 41-43.

56. KAMPRATH, E. J. and G. W. FITTS. 1960. Interpretation of soil tests and application as charted by current research. Agric. and Food Chemistry, (8)2:94-96. Bibliog. 8 refs.

57. MASS, H. C. 1960. Mapping our soils—the work of Canadian soil surveys. Agric. Inst. Rev. Canada, (15)2:13-14.

58. MATHEWS, B. C. and R. W. BARIL. 1960. Soils of the Great Lakes—St. Lawrence Lowlands. Agric. Inst. Rev. Canada, (15)2:37-40.

59. NOWOSAD, F. S. and A. LEABEY. 1960. Soils of the arctic and subarctic regions. Agric. Inst. Rev. Canada, (15)2:48-50.

60. PAPADAKIS, J. 1960. A note on the formation of clay horizons (textural B). Soils and Fertilizers, No. 1, p. 7.

61. RAVIKOVITCH, S. 1953. The eolian soils of the Northern Negev. In: Desert research. Jerusalem, pp. 404-433.

62. SHERMAN, G. D. 1959. Nature and types of secondary mineral aggregates, concretions, nodules and layers of soils. J. Indian Soc. Soil Sci., No. 4:193-197.

63. WIJK, W. R. VAN. 1959. Soil salinity course in Tunisia. Nature, 134(4701): 1778-1779.

SOIL MINERALOGY

64. MAVLYANOV, G. A. and N. I. GRIDNEV. 1960. Mineral composition of the loesses and loess-like soil materials of Fergana and its connection with the parent materials. Uzbek geol. zh., No. 2:28-32. Summary in Uzbek.

65. OLYUNIN, V. N. and YE. I. SOKOLOVA. 1960. The mineralogical composition of certain loess-like deposits in the Fergana foothill districts. Tr. In-ta geogr. Akad. Nauk SSSR, Vol. 80:118-123. Bibliog. pp. 122-123.

66. SHAROSHKINA, N. B. 1960. Mineralogical description of the clay fraction of solonetz soils. Izv. Akad. Nauk KazSSR, Ser. botan. i pochvoved., No. 2:46-54. Bibliog. p. 54. Summary in Kazakh.

67. KITTRICK, J. A. 1960. Cholesterol as a standard in the X-ray diffraction of clay minerals. Soil Science Soc. America Proc., (24)1:17-20.

68. McATEE, J. L. 1959. Inorganic-organic cation exchange on montmorillonite. Amer. Mineralogist, (44)11:1230-1236.

69. MITRA, R. P. 1959. Some recent developments in the field of fundamental clay research. J. Indian Soc. Soil Sci., pp. 207-211.

70. RICH, C. I. 1960. Aluminum in interlayers of vermiculite. Soil Sci. Soc. America, Proc. (24)1:26-32.

PHYSICAL PROPERTIES OF SOILS AND METHODS OF INVESTIGATION

71. VERONIN, A. D. 1952. Composition and properties of separates in the soil complex of the light-chestnut subzone. Author's summary of Candidature thesis (Moscow Univ., Biol.-Soil Faculty). Moscow, 22 pp.

72. GARKUSHA, I. F. 1959. Soil structure. Lectures for agricultural faculty students. Belorussian Agric. Acad., Gorki, 14 pp.

73. GLOBUS, A. M. 1960. Experimental study of the phase composition of soil moisture on migration under the influence of temperature gradient. Doklady Akad. Nauk SSSR, (132)4:918-920. Bibliog. 7 refs.

74. DMITRIYEVA, N. V. 1960. The use of hygroscopic moisture figures in describing soils by texture. Interim communication. Tr. Pochv. in-ta Mold. f-la Akad. Nauk SSSR, No. 4:97-103. Summary in Moldavian.

75. DMITRIYEVA, N. V. and N. I. ROGOVSKAYA. Preparing soils for particle-size analysis. Op. cit., 85-95. Bibliog. 7 refs. Summary in Moldavian.

76. DUBROVSKIY, A. A. 1959. The possibility of making implements to work the soil by vibration. Moscow. Izd. M-va s.-kh. RSFSR, 48 pp.

77. ZHURAVLEV, M. Z. 1959. Water regime of the forest steppe chernozem of West Siberia. Tr. Omsk. s.-kh. in-ta, Vol. 36:1-142, illustr. Bibliog. 157 refs.

78. OKUNEVA, M. I. 1959. Features of the water regime and precipitation of peat from small drained peat bogs. Author's summary of Candidature thesis (All-Union Res. Inst. for Water Engineering and Melioration). Moscow, 18 pp.

79. PODVOYSKIY, M. F. 1960. Change in the water and air regime of sod-podzolic fine clay loam soils on cultivation. Author's summary of Candidature thesis (Leningrad Agric. Inst.). Leningrad-Pushkin, 19 pp.

80. KIRILLOV, M. V. 1960. Drought fissures and frost shakes in the forest steppe districts of the Krasnoyarsk region. Izv. Krans. otd. Vsesoyuzn. geogr. o-va, (30)1:100-101.

81. GREACON, E. L. 1959. Swelling forces in straining clays. Nature, No. 4700, 1695-1697.

82. PARCHER, J. V. and R. E. MEANS. 1959. Soil conditions and termite control. 3. Classification and identification of cohesionless, cohesive soil. Pest Control, (27)4:50-54.

83. PHILLIPS, R. E. et al. 1960. Use of radiation equipment for plowlayer density and moisture. Soil Sci. 89(1):2-7.

84. Recent research on soil-water relations. 1960. J. Agric., (58)4:215-216.

85. SCHAFFER, G. 1960. Die Strukturzerfallsneigung der Ackerkrume in Abhaengigkeit vom Wassergehait des Bodens. Ztschr. Acker und Pflanzbau, (110)3:255-266. Bibliog. 20 refs.

SOIL CHEMISTRY AND METHODS OF ANALYSIS

86. VASIL'YEVSKAYA, V. D. 1959. Microelements cobalt, nickel, copper, and zinc in soils, plants and natural waters of the upper Amur region. Author's summary of Candidature thesis (Moscow State Univ., Biol. and Soil Faculty). Moscow, 20 pp.

87. VOLOKHOVA, A. A. 1959. Soil solution from the lower reaches of the Syr-Dar'ya River. Author's summary of Candidature thesis (Kazakh State Univ., Biol. -Soil Faculty). Alma-Ata, 16 pp.

88. GRABAROV, P. G. 1960. Humus and nitrogen content in the carbon nitrogen ratio in the soils of the Kazakh SSR. Izv. Akad. Nauk KazSSR, Ser. botan. i pochvoved., No. 2:24-35. Bibliog. 5 refs. Summary in Kazakh.

89. GRABAROV, P. G. and B. N. VISHEVSKAYA. Comparative changes in total nitrogen in soils. Op. cit., 55-60. Bibliog. 9 refs. Summary in Kazakh.

90. DRUZHININ, I. G. and A. YE. KHARAKOZ. 1959. Physicochemical description of the peat of Kirgizia. Izd. Akad. Nauk Kirgiz. SSR (Inst. khimii), Frunze, 97 pp., illustr. Bibliog. 41 refs.

91. DYUKOVA, A. P. 1960. Composition of humic matter in flood plain soils. Nauchn. dokl. vyssh. shkoly, Biol. nauki, No. 2: 198-202. Bibliog. 5 refs.

92. KOVDA, V. A., I. V. YAKUSHEVSKAYA, and A. N. TYURYUKANOV. 1959. Microelements in the soils of the Soviet Union. Moscow, Izd. Mosk. Un-ta, 67 pp., illustr. Bibliog. pp. 63-66.

93. MEZHENIN, I. S. 1960. The pH value of a water suspension of soil for various ratios of the soil to the water. Izvestiya Akad. Nauk KazakhSSR, Ser. botan. i pochvoved., No. 2:68-70. Summary in Kazakh.

PEYVE, YA. B. (Edit.). 1959. Procedures for determination of microelements in soils and plants. Riga, Izd. Akad. Nauk LatvSSR, 46 pp.

NOSOV, P. V. 1959. Description of the phosphate regime of Western Ciscaucasian leached chernozem. Author's summary of Candidature thesis (Stalingrad Agric. Inst.), 24 pp.

NOSOV, P. V. 1960. Phosphate content in the fields of a grassland farming rotation. Nauchn. dokl. vyssh. shkoly, Biol. nauki, No. 2:203-206. Bibliog. 9 refs.

RINKJIS, G. YA. 1959. Methods for rapid determination of microelements (Cu, Zn, Mn, Co, Mo and B) in soils and plants. Author's summary of Candidature thesis (Latvian Agric. Acad.), Riga, 30 pp.

SERDOBOL'SKIY, I. P. 1959. Soil chemistry. Tbilisi, Izd. Gruz. s.kh. in-ta, 159 pp., illustr. (In Georgian).

SIRENKO, N. A. 1959. Forms of nitrogen in the chernozems of the Ukrainian SSR in relation to the efficiency of nitrogenous fertilizers, grass cultivation, and green manuring with or without irrigation. Author's summary of Candidature thesis (Ukr. Inst. for Plant Physiology). Kiev, 20 pp.

ALLISON, L. E. 1960. Wet-combustion apparatus and procedure for organic and inorganic carbon in soil. Soil Sci. Soc. America, Proc., (24)1:36-40.

BERG, W. A. and G. W. THOMAS. 1959. Anion elution patterns from soils and soil clays. Soil Sci. Soc. America, Proc., (23)5:348-50.

DIETZ, R. 1959. Pruefung der Boden auf den Gehalt an pflanzen schaedlichen mineralischen Salzen. Bodenkultur, Pt. A, (10)4:306-310.

GRACANIN, M. 1959. Die Bodenphosphatisierung im Lichte Bodentypologischer Forschungen. Agrochimica, (3)3:244-261.

GUSTAFSON, P. F. 1959. Ratio of cesium-137 and strontium-90 radioactivity in soil. Science, (130)3386:1404-1405.

HILTBOLD, A. A. and F. ADAMS. 1960. Effect of nitrogen volatilization on soil acidity changes due to applied nitrogen. Soil Sci. Soc. America, Proc., (24)1:45-47.

HOFFMAN, E. et al. 1959. Loeslichkeit und Wirkung der Phosphorsauere verschiedener Phosphate. Landwirtsch. Forsch., (12)4:270-275.

KARBACH, L. 1959. Potentiometrische Bestimmung von Eisen in Boden. 2. Bestimmung des Verhaeltnisses vom zwei- zu dreiwertigen Eisenionen. Landwirtsch. Forsch., No. 12:239-252.

108. KATAOKA, I. and T. KITAMURA. 1959. Studies on "brown gel" (hydrated ferric oxide). 3. The relationship between drying and aging of the gel. J. Sci. Soil Tokyo, No. 30:18-22.

109. KICH, H. and H. ARENT. 1959. Die Extraktion des Germaniums aus Boeden. Z. Pflanzenernaehr. Dueng., Bodenkunde, 88 (132)3:212-216.

110. MILLER, J. R. 1960. Research in Maryland on chemical methods for determining available phosphorus and potassium in soils. Agric. and Food Chemistry, (8)2:81-87.

111. OGATA, G. and A. C. CALDWELL. 1960. Nitrate content of soils and nitrogen content of oat plants as affected by rates of liming. Agron. J., No. 2:65-68.

112. Radioisotope in der Bodenkunde. 1960. Bibliographie. Atomkern Energie, (5)5: 199-200. Bibliog. 29 refs.

113. RAUPACH, M. and C. S. PIPER. 1959. Interactions of silicate and phosphate in a lateritic soil. Austr. J. Agric. Res., (10)6:818-831.

114. SAUNDERS, W. M. H. 1959. Aluminium extracted by neutral citratedithionite reagent. Nature, (184)4704:2307.

115. SCHULS, R. K. et al. 1960. On the soil chemistry of cesium-137. Soil Sci., (89)1: 16-27.

116. SILLANPAA, M. 1958. Soil testing as an index of phosphorus and potassium balances in the soil. Helsinki, 19 pp.

117. SINHA, P. et al. 1959. Nature of nitrogen mineralization and carbon dioxide evolution in some typical Bihar soils. J. Soil and Water Conservat. India, (7)2-3:88-97.

118. TENDILLE, C. 1959. Sur les mouvements de diffusion des ions phosphoriques dans le particules du sol etudies a l'aide de 32 P. Bull. Assoc. franc. Etude Sol., No. 11:527-534.

119. TOTH, S. J. and R. B. ALDERFER. 1960. A procedure for tagging waterstable soil aggregates with Co^{60}. Soil Sci., (89)1:36-37.

120. YU, T. J. et al. 1958. Influence of soil reaction on the activity of manganese. Proc. Soil Inst. Pekin, No. 33:16-30.

SOIL BIOLOGY AND MICROBIOLOGY

121. Bacterial fertilizers and their use. 1959. (Collected papers of scientific meeting). Izd. Ukr. akad. s.-kh. nauk, 191, illustr. (In Ukrainian).

122. BELOV, YE. A. 1960. The influence of organo-mineral fertilizers on soil microfauna and plant root systems. Author's summary of Candidature thesis. (Kishinev Agric. Inst.). Kishinev, 17 pp.

BIBLIOGRAPHY

123. BLINKOV, G. N. 1959. *Azotobacter* and its significance to higher plants. Tomsk. Izd. Tomsk. un-ta, 254 pp. Bibliog. pp. 222-253.

124. GROMOV, B. V. 1959. Significance of nutrient concentration when studying soil microorganisms. Author's summary of Candidature thesis (Leningrad State Univ.) Leningrad, 16 pp.

125. GROMYKO, I. D. and YE. V. KULAKOV. 1960. Change in the physico-chemical and biological properties of the virgin chernozems of Northern Kazakhstan when they are plowed. Izv. Timiryaz. s.-kh. akad., No. 2:85-94. Bibliog. 5 refs.

126. DARZNIYEK, YU. O. 1960. Vertical distribution of *Azotobacter* cells in old-irrigated soils of the Murgab oasis. Izv. Akad. Nauk TurkmSSR, Ser. biol. nauk, No. 1:9-14. Bibliog. 5 refs.

127. YEZUBCHIK, A. A. 1959. Microflora of the main soil groups of the Poles'ye lowland and ways of activating it. Author's summary of Doctorate thesis (Belorussian Agric. Res. Inst. Acad. Sci. BSSR), Minsk, 44 pp.

128. KISELEVA, N. T. and L. N. PALETSKAYA. 1960. All-Union Conference on Soil Microbiology, Leningrad, Nov. 1959. Izv. Akad. Nauk SturkmSSR, Ser. biol. nauk, No. 1:87-89.

129. MALAKHOVA, P. T. 1959. Microflora of alfalfa rhizosphere from typical irrigated sierozem. Author's summary of Candidature thesis (Botan. Inst. Acad. Sci. Uzb SSR), Tashkent, 17 pp.

130. SAMOYLOV, I. I. 1959. (Gen. Edit.). Microbiology in the service of agriculture. VASKHNIL, Sel'khozgiz, 310 pp., illustr.

131. PETROSYAN, A. P. 1959. Ecological features of nodule bacteria of ArmeniaSSR. Yerevan, Izd. M-va s.-kh. ArmSSR, 280 pp., illustr.

132. POVALYAYEVA, I. P. 1960. Relationship of distribution of grass to texture and humification of sandy soils and dry pine forests in the Irtysh region. Nauchn. dokl. vyssh. shkoly, Biol. nauki, No. 2, pp. 128-131.

133. POPOVA, YE. G. 1960. Microflora of takyrs in relation to the problem of their agricultural use. Author's summary of Candidature thesis (Inst. Microbiol. Acad. Sci. USSR), 23 pp.

134. SIDORENKO, A. I. 1959. Microbiological description of the chestnut-brown soils of Central Kulunda: Izv. Sib. otd. Akad. Nauk SSSR, No. 9:103-110. Bibliog. 10 refs.

135. FEDOROV, M. V. and T. A. KALININSKAYA. 1960. The relationships between various species of oligonitrophilous bacteria that fix molecular nitrogen in mixed crops. Izv. Timiryaz. s.-kh. akad., No. 2:125-136.

136. CHEKANOVSKAYA, O. V. 1960. Earth worms and soil formation. Izd. Akad. Nauk SSSR (Popular science series), 216 pp., illustr. Bibliog. pp. 192-201.

137. SHAPOVALOV, V. P. 1959. Effect of temperature and moisture on the decomposition of plant residues in the chernozems of Northern Kulunda. Izv. Sib. otd. Akad. Nauk SSSR, No. 9:98-102.

138. SHEVTSOVA, I. N. 1959. Variation in the properties of certain soil bacteria in the rhizosphere of agricultural crops. Author's summary of Candidature thesis (Kiev Univ., Microbiol. and antibiotic faculty), Kiev, 16 pp.

139. SAMTSEVICH, S. A. et al. (Edit. VLASYUK). 1959. The efficiency of bacterial fertilizers in the Ukraine. Kiev, Izd. UASKhN, 57 pp. (In Ukrainian).

140. BENTON, A. H. and W. E. WERNER. 1958. Principles of field biology and ecology. New York, 341 pp.

141. BIRIE, A. 1959. Un grand probleme humain-L'Humus. Paris. 112 pp.

142. BORUT, S. 1960. An ecological and physiological study on soil fungi of the Northern Negev (Israel). Bull. Res. Council, Israel, 8D:65-80.

143. COLLIS-GEORGE, N. 1959. The physical environment of soil animals. Ecology, 40(4):550-557.

144. COUCH, H. B. and J. R. BLOOM. 1960. Influence of soil moisture stresses on the development of the root knot nematode. Phytopathology, (50)4:319-321.

145. GUTSCHY, L. 1959. Eine mikrobiologische Methode zur quantitativen Bestimmung der pflanzenaufnehmbaeren Naehrstoffe im Boden. Z. Pflanzenernaehr. Dueng., Bodenkunde, 87(132)3:193-201.

146. HADFIELD, W. 1960. Rhizosphere effect on soil algae. Nature, No. 4707:179-180.

147. HOMRIGHAUSEN, E. and W. ROHMER. 1959. Untersuchungen verscheidener Dispergierungsverfahren bei der Vorbehandlung zur fluorescenzmikroskopischen Keimzahlung in Boeden. Landwirtsch. Forschung, (12)4:253-260.

148. IVARSON, K. C. and H. KATZNELSON. 1960. Studies on the rhizosphere microflora of yellow birch seedlings. Plant and Soil, No. 1:39-40.

149. JEANSON-LUUSINANG, C. 1960. Etude experimentale de l'action de *Lumbricus herculens* Savigny (Oligochete, Lumbricide) sur la stabilite structurale des terres. Compt. Rend. Acad. Sci., (250)18:3041-3043.

150. JEANSON-LUUSINANG, C. 1960. Evolution

de la matiere organique du sol sous l'action de Lumbricus herculens Savigny (Oligochete, Lumbricidae). Compt. Rend. Acad. Sci., (250)21:3500-3502.

MARSHALL, K. C. et al. 1960. Problems in the use of agar for the enumeration of soil microorganisms. Soil Sci. Soc. America, Proc., (24)1:61-62.

MELLANBY, K. 1960. The biological importance of the invertebrate soil fauna. Soils and Fertilizers, No. 1:8-9.

ROSS, D. J. 1960. A note on the occurrence of non-symbiotic nitrogen-fixing bacteria in some introduced pasture soils. N. Z. J. Agric. Res., (3)2:245-249. Bibliog. 8 refs.

CUMBER, R. A. 1960. Insects revealed in studies of soil, turf and dung. N. Z. J. Agric. Res., (3)2:253-267. Bibliog. 18 refs. (Contribution No. 10 to "The insect complex of sown pastures in the North Island").

SOIL FERTILITY, FERTILIZERS, AND TILLAGE

AKIMTSEV, V. V. 1960. What are micronutrient fertilizers and how should they be used in agriculture. Rostov on Don. Izd. Rost. in-ta, 19 pp.

BALEV, P. M. 1960. Peaty-podzolized soils and methods for improving their fertility. VDNKh, Moscow, 26 pp., illustr. Bibliog. 12 refs.

VOYKIY, L. M. 1959. Forms of phosphates, adsorption and conversion of phosphorous fertilizers in the soils of the Tatar ASSR. Author's summary of Candidature thesis. (Kazan Univ.). Kazan, 17 pp.

VOLKOVA, R. V. 1960. A study of ways of tilling black fallow in the chestnut soil zone of the Stalingrad Oblast'. Author's summary of Candidature thesis. (Stalingrad Agric. Inst.). Stalingrad, 22 pp.

VYSHINSKIY, A. M., P. A. DMITRENKO, and I. L. KOLOSHA. 1959. Fertilizers and their use. Kiev, Gossel'khozizdat UkrSSR, 394 pp., illustr. Bibliog. 24 refs.

GORYANSKIY, M. M. 1960. Role of bare fallows in the arid steppe of the Ukraine. Zemledeliye, No. 6:40-45.

GULYAKIN, I. V. 1960. The principles of a rational fertilizer system in a non-chernozem zone. Izv. Timiryaz. s.-kh. akad., No. 2:53:60. Bibliography 5 refs.

DOMASKINA, A. S. 1959. Influence of perennial grasses on the fertility of meadow-chernozems of the Dniester region. Author's summary of Candidature thesis. (Odessa Agric. Inst.). Odessa. 16 pp.

163. DUKHANIN, A. A. 1959. Increasing the productivity of coarse-textured soils in relation to their cultivation. Udob. i urozhay, No. 12:16-20.

164. ZELENIN, N. N. 1960. The efficiency of phosphorous fertilizers prepared from Kara-Tau rock phosphates. S.-kh. Uzbekistana, No. 5:86-88.

165. ZIGANSHINA, V. S. 1959. An evaluation of moldboard and non-moldboard plowing on sod-podzolic soils of the Tatar ASSR. Author's summary of Candidature thesis. (Stalingrad Agric. Inst.). Kazan, 17 pp.

166. KALININ, K. V. 1959. The influence of the form of fertilizer on yield and phosphorous uptake by plants. Author's summary of Candidature thesis (Timiryazev Acad. Moscow). 18 pp.

167. KASATKIN, A. N. 1960. Agricultural physical evaluation of the quality of high speed plowing. Author's summary of Candidature thesis. (VASKhNIL, Agrophysical Res. Inst.), Leningrad, 14 pp.

168. KIRNITSKIY, B. T. 1960. Features of the utilization of perennial grass sod under Moldavian conditions. Tr. Mold. n.-i. in-ta s.kh., Vol. 2:5-50. Bibliog. 83 refs.

169. KOLESNIK, I. L. and P. M. KUROCHKIN. 1960. Features of fall plowing in the southern Ukrainian steppe. Zemledeliye, No. 6:87-88.

170. KORABLEVA, L. I. 1960. The scientific use of fertilizers. Moscow, Znaniye, 40 pp., illustr.

171. KUZNETSOVA, A. V. 1960. The accumulation and retention of mineral forms of nitrogen in the chernozems of the Southern Urals. Author's summary of Doctorate thesis. (Voronezh Agric. Inst.). Voronezh.

172. MAGNITSKIY, K. P., YU. A. SHUGAROV, and V. K. MALKOV. 1959. New methods of plant and soil analysis. Moscow, Sel'khozgiz, 240 pp., illustr. Bibliog. 186 refs.

173. MIROSHNICHENKO, V. G. 1959. The efficiency of main moldboard and non-moldboard plowing for winter and spring wheat in the central area of the non-chernozem belt. Author's summary of Candidature thesis (Timiryazev Acad. Moscow), 25 pp.

174. MOVSISYAN, YE. M. 1959. Agricultural chemical studies of carbonate regime and humus in Ararat plain soils. Author's summary of Doctorate thesis (Dokuchayev Soil Inst., Acad. Sci. USSR). Yerevan, 35 pp., illustr.

175. MUKAL'YANTS, V. M. 1959. The effect of primary tillage methods on the fertility of layers of a typical irrigated sierozem with an alfalfa sod. S. kh. Uzbekistana, No. 11: 26-31.

176. MUSTAFAYEV, KH. M. 1960. The harmful

effect of intensified pasturing on the soil. Dokl. Akad. Nauk AzerbSSR, (16)2:175-177.

177. NARTSISSOV, V. P. 1959. Fertility indices for grey forest soils and leached chernozems of the Gor'kovskaya Oblast' and the Chuvash ASSR. Gork. s.-kh. in-t, Gorki, 97 pp., illustr. Bibliog. 154 refs.

178. NEUBERG YAROSLAV, 1959. Aspects of the agricultural chemistry of strontium-90. Author's summary of Candidature thesis (Timiryazev Acad. Moscow). 17 pp.

179. OGANOV, G. M. 1960. Increasing the fertility of soils suitable for tea and the tea plantation soils of the Lenkoran subtropics in Azerbaydzhan. Author's summary of Doctorate thesis (Dokuchayev Soil Inst., Acad. Sci. USSR), Moscow, 36 pp.

180. PAVLOV, A. V. 1960. Winter field irrigation to increase crop yields. Moscow. Izd. Akad. Nauk SSSR (In-t merzlotovedeniya), 70 pp., illustr. Bibliog. pp. 67-69.

181. PETERBURGSKIY, A. V. 1960. Production and use of compound fertilizers in France. Moscow. Izd. M-va s.kh. SSSR, 80 pp., illustr.

182. PETERBURGSKIY, A. V. 1959. Exchange adsorption in the soil and plant uptake of nutrients. Moscow, Vyssh. shkola, 251 pp., illustr. Bibliog. pp. 235-249.

183. PIL'KO, V. M. 1959. Soil fertility in the BSSR. Minsk, Gosizdat BSSR, 195 pp., illustr. Bibliog. pp. 189-194.

184. SATINSKIY, YU. V. 1960. Comparative study of various tillage methods and depths of primary tillage for grain and row crops in the southeast of European Russia. Author's summary of Candidature thesis (Timiryazev Acad. Moscow). 18 pp.

185. SAUKEVICHUS, B. P. 1960. The effect of deep plowing and mole drainage on fertility of mineral soils under Lithuanian conditions. Author's summary of Candidature thesis (Lith. Agric. Acad.). Kaunas, 24 pp., illustr.

186. SLAVNINA, T. P. 1959. The effect of desalinization on the content and availability of nutrients in meadow solonchaks. Baraba. Izv. Sib. otd. Akad. Nauk SSSR, No. 7:89-95. Bibliog. 5 refs.

187. TONKUNAS, I. M. 1959. Utilization of the nitrogen of mineral fertilizers and biological nitrogen in cultivated pastures. Udobreniye i urozhay, No. 12:27-31.

188. TSIBUL'SKIY, V. F. 1960. Mixing of phosphorous fertilizers in the soil by irrigations and inter-row cultivation of cotton for various types of superphosphate placement S. kh. Uzbekistana, No. 5:13-17.

189. CHIZHEVSKIY, M. G. 1960. Basic problems of soil tillage in the natural regions of the USSR. Izv. Timiryaz. s.-kh. akad., No. 1:39-52.

190. SHUBIN, V. F. 1959. Bringing the chestnut soils of the Volga region under cultivation. Moscow. Izd. Akad. Nauk SSSR, 136 pp., map. Bibliog. pp. 134-135.

INDEX OF MATERIAL PUBLISHED IN 1960

TABLE OF CONTENTS NOS. 1-12

Number

D EL-SAMI, AHMED HAMAL, Use of Sprinkling Irrigation in Reclamation of Sandy Soils on the Inchas Farm in Egypt 12

ERIKHIN, P. G., YE. P. TIKHOVA, V. P. KULAKOV and N. YA. DEGTYAREVA, Changes in the Podzolic Soils of the Murmansk Region Under Cultivation 4

EKSIN, A. A., The Importance of the Crypto-Geological Structure of Central Asian Alluvial Plains for Reclamation Purposes 2

DREYEVA, YE. A., Natural Soil Radioactivity and Determination of Total Potassium by a Radiometric Method 5

SING, I. A., Some Features of Humus Formation in Mountain Soils of Northern Tien-Shan 12

DONIN, N. S., I. P. ARENS, and L. N. STEPANOVA, Influence of Fertilizers on the Properties of Sod-Podzolic Soils 9

DANOVA, YE. A., The Role of Mineral Fertilizers in Irrigated Agriculture on Buryat Chestnut Soils 10

KHTON, P. V. and A. S. L'VOV, Hardness Dynamics of Certain Soils in the Middle Trans-Volga and South-Urals Regions 5

AZHNIY, YE. S., and YU. N. BAGROV, Physical Properties of Compact Chernozems 12

GATYREV, K. P., Red Weathering-Crust Soils of Albania 10

ROV, D. I. and I. A. CHUDANOV, Annual Crops as a Factor in the Aggregation and Structure Development of Chernozem Soils 11

TUZOVA, O. V., Characteristics of Certain Soils of the Pskov Oblast' 7

ALYY, A. M., Problem of the Water Balance and Moisture Cycle Under Conditions in the Southeast 9

ALYY, A. M., Soil Moisture Cycle of the Plow Layer 1

CHKOV, V. I., Soil Erosion in the Forest-Steppe Districts of the Angara 8

AGINA, YE. G., Soil Formation in the Low Mountain Region of the North Altai 6

IZHIKOV, P. N., A Map of the Native Soil-Forming Parent Materials of the European Part of the USSR 5

RASELIYA, N. A., Dynamics of Microbiological Processes in the Red Earths of Tea Plantations in Soviet Georgia 8

December Plenum of the Central Committee of the Communist Party of the Soviet Union 1

INDEX

	Number
DMITRENKO, P.A. and L.A. SHEVCHENKO, Increasing the Effectiveness of the Residual Effect of Phosphorous Fertilizers	7
DOBROVOL'SKIY, G.V. and N.F. TITKOVA, Characteristics of Soil Structure in Flood-Plain Oak Stands	1
DOBROVOL'SKIY, G.V., I.P. BABAYEVA, and A.P. LOBUTEV, Characterization of the Moisture Properties, Gas Phase, and the Microflora of Flood-Plain Soils	11
DOBROVOL'SKIY, V.V., Microelements in Several Soils and Soil-Forming Parent Materials of Kazakhstan	2
DURASOV, A.M., Chernozems of the Trans-Ili Ala-Tau	5
DURASOV, A.M., Dark Chestnut Carbonate Solonetz-Like Soils of Northern Kazakhstan	2
FIRSOVA, V.P., Mantled Clay Loams of the Southeastern and Central Parts of the Russian Plain as Soil-Forming Parent Material	11
GODLIN, M.M., Deepening of the Plowing Layer and Radical Alteration of the Profile in Podzolic and Sod-Podzolic Soils of Different Texture	8
GRADUSOV, B.P., Chemical and Mineralogical Characterization of Soils in the Central Part of the Karelia Isthmus	7
GRIGOR'YEV, G.I., Diagnostic Indices of Sod-Poczolic Soils at Various Levels of Cultivation	6
KARAVAYEVA, N.A., and V.O. TARGUL'YAN, Humus Distribution in the Tundra Soils of Northern Yakutia	12
KARMANOV, I.I., Soils of the Rice Fields of Lower Burma and of Certain other Regions of the Burmese Union	8
KARPACHEVSKIY, L.O., Micromorphological Study of Leaching and Podzolization of Soils in a Forest	5
KAURICHEV, I.S., YE.A. FEDOROV, and I.A. SHNABEL', Separation of Humic Acids by the Continuous Paper-Electrophoresis Method	10
KAURICHEV, I.S., and YE.M. NOZDRUNOVA, Calculation of the Migration of Certain Compounds in Soil by Using Chromatographic Columns of Lysimeters	12
KAZIYEV, M.Z., and KH.Z. UMAROV, Influence of Potassium Fertilizers on the Yield of Hay and Alfalfa Roots on Meadow Soils in the Irrigated Zone of Central Asia	7
KHITROV, L.M. and I.K. ZADOROZHNYY, Fractionation of Isotope Oxygen in the Soil	1
KIR'YANOV, G.F., The Philosophical Foundation of V.V. Dokuchayev's Scientific Work	10
KOLOSKOVA, A.V., Physical Properties of Light-Gray Forest Soils in the Tatar ASSR	3
KONONOVA, M.M. and K.V. D'YAKONOVA, Soil Organic Matter and Aspects of Plant Nutrition	3
KONONOVA, M.M. and N.P. BEL'CHIKOVA, Investigation of the Nature of Soil Humus Substances by Fractionation	11
KOROTKOV, A.A., Modification of Sod-Podzolic Soils Under Meadow Vegetation	9
KOSOV, B.F., Zonality of Gully Erosion in the European USSR	8
KOVDA, V.A., B.A. ZIMOVETS, N.G. ZYRIN, E.A. KORNBLYUM, and V.D. VASIL'YEVSKAYA, Soils and Soil-Formation Processes in the Upper and Central Amur Bottom Land	11

INDEX

Number

KUDZIN, YU. K., Response of Corn, Sugar Beet, and Potatoes to Changes in The Nutrient Regime of the Soil after Continuous Application of Fertilizers 6

KUKHARENKO, T. A. and L. N. YEKATERINA, Hyatomelanic Acids of Fossil Coals 12

KULAKOV, YE. V., Distribution Patterns of Organic Residues in the Profile of Chernozems in Northern Kazakhstan 3

KURCHEVA, G. F., Role of Invertebrates in the Decomposition of Oak Litter 4

LEVINA, V. I., Characteristics of the Exchange of Mineral Elements Between Moss-Lichen-Shrub Vegetation and Soil in Two Types of Pine Forest in the Kola Peninsula 5

LIVEROVSKIY, YA. A., The Work of N. M. Sibirtsev on the Classification and Mapping of Soils 7

LOBOVA, YE. V., The Soils of Ghana — Seventh International Conference of West African Countries (CIAO) 1

MAMAYEV, B. M. and D. F. SOKOLOV, Role of Invertebrates in the Natural Destruction of Oak Wood 4

MARCHENKO, A. I., Characteristics of Soils of the Kargopol'skaya Dry Land 11

MARKOV, YE. S., Water-Logged Flood Plains and Methods of Their Reclamation 8

MONTULYAK, G. S., Dynamics of Soil Organic Matter Under Continuous Rye 3

MONTUZOV, YA. YA., Effect of Frost on the Structure and Erosion Resistance of the Soil in Relation to its Moisture 3

NAUMOV, YE. M., Genesis of the Second Humus Horizon in the Grey Forest Soils of the Krasnoyarsk Region 3

On The 90th Anniversary of the Birth of Vladimir Il'ich Lenin 4

ORLOV, A. YA., and A. A. IZVEKOV, Effects of Drainage on the Forest-Growing Properties of Peat-Humus Soils 2

PARFENOVA, YE. I., and YE. A. YARILOVA, The Problem of Lessivage and Podzolization 9

PEKATOROS, L. G., Process of Salt Accumulation in Soils of the Southern Bug Flood Plain 8

PEYVE, YA. V., Boron and Molybdenum in Latvian Soils 9

POKHITON, P. P., The Role of Shrub Roots in Supplying Soil with Organic Matter and Nitrogen 12

POPOV, A. A., Change in Soil Meliorative Conditions After Diking the Volga-Akhtuba Flood Plain 7

POPOV, A. A., Classification of Alluvial Soils of the Volga-Akhtuba Flood-Plain and the Volga Delta 5

PUSTOVOYTOV, N. Z., Outline of Principles for the Reclamation of Soils in the Amur Oblast' 10

P'YAVCHENKO, N. I., The Biological Cycle of Nitrogen and Ash Elements in Bog Forests 6

RODE, A. A., YE. A. YARILOVA, and I. M. RASHEVSKAYA, Certain Genetic Characteristics of Dark Soils of Large Depressions 8

RODE, T. A. and I. A. SOKOLOV, The Transbaykal Mountain-Tundra Landscapes 4

RUBINSHTEYN, YE. S., Some Data on the Thermal Regime of USSR Soils 10

RYBTSOV, D. M., Podzolic-Bog Soils 7

INDEX

	Number
RYZHOV, S. N., Distribution of Readily Mobile Water in Soils and Soil Materials of Varying Structure	11
SELIVANOV, A. P., Water-Stability of the Structure of Different Soil Groups and its Dependence on Agricultural Practices	3
SELL'-BEKMAN, I. YA., V. A. RABINOVICH, and O. V. KUROVSKAYA, Oxidation-Reduction Potential Profile Curves in Relation to the Conditions of Soil Formation	6
SHUBIN, V., The Role of N. M. Sibirtsev in the Establishment of Experimental Fields in the Nizhniy Novgorod Government	7
SHUMAKOV, V. S., Biochemical Activity of a Dark Gray Forest-Steppe Soil Under Various Forest Plantations	10
SOBOLEV, S. S., The Life and Work of Nikolay Mikhaylovich Sibirtsev	7
SOKOLOV, A. A., and N. I. KOTIN, Lithogenic Soil Complexes in the Southeastern Part of the Kazakh Low-Hill Plain	10
SOKOLOV, A. A., R. DZHANPEISOV, and N. I. KOTIN, Eolian Meadow-Steppe Solonetz Complexes of the Middle Irtysh Region	7
SOKOLOV, D. F., Seasonal Changes in the Humus and Nitrogen Content of Shallow Chernozems in Forest Plantations	6
SOKOLOVSKIY, S. P., Characterization of the Present Saline Soils in the Terek River Delta	5
STAPRENS, V. YA., Translational Migration of Capillary-Suspended Moisture in Sandy Soil Materials	4
SUKACHEV, V. N., Relationship of Biogeocoenosis, Ecosystem, and Facies	6
SHUKHAREV, I. P., Depth of Wetting of Chernozem Soils After Irrigation	1
SURMACH, G. P., Problem of the Genesis of Relief and Syrt Deposits in the Trans-Volga Region	9
SUSHKINA, N. N., Characteristics of the Microflora of Arctic Soils	4
SVIRIDOVA, I. K., Role of Improvement cuttings in Raising Forest Soil Fertility	4
TAYCHINOV, S. N., and M. M. FAYZULLIN, Nitrate Changes Associated with the Relief and Erosion of Soils	4
TOCHILOV, V. I., Theory of the Condensation of Atmospheric Moisture in Soil	2
TRUSHIN, V. F., Means of Increasing the Waterholding Capacity of Soils	11
TURCHIN, F. V., Prospects for the Application of Mineral Fertilizers in the USSR	5
TYURIN, I. V., 100th Anniversary of the Birth of Nikolay Mikhaylovich Sibirtsev	7
VLADYCHENSKIY, S. A., Effect of the Veselovskoye Reservoir on Soils of Adjacent Areas	2
VOZBUTSKAYA, A. YE., Role of Soil-Adsorbed Ammonium in the Nitrogen Nutrition of Plants	2
VADYUNINA, A. F., Changes in the Physical Properties of Yergeni Solonetzes Under the Influence of Shrubs	4
VASIL'YEV, I. S., and A. A. RODE, "Labeling" Soil Moisture with Chloride Ion to Study its Movement Under Field Conditions	4
VORONOVA, YE. P., Soil Formation Processes and the Classification of Flood-Plain Soils in the Steppe Zone of the Central Chernozem Belt	7

INDEX

	Number
YAKUBOV, T. F., Effect of Wind Erosion Upon Some Physical and Chemical Properties of Soils	12
ZAKHARCHENKO, I. G., Soil-Water Regime in a Grain-Beet Rotation	3
ZAKHAROV, P. S., Distribution of Dust Storms in the Northern Caucasus and an Experiment on Their Control by Means of Forest Belts	9
ZONN, S. V., and I. I. FEOFAROVA, A New Group of Soils Under Dark Coniferous Forests in Eastern Tibet	6
ZONN, S. V., and LI CHEN-KUEI, Biological Energy Exchange Processes in Tropical Forest Soils	12

DISCUSSION

BOLYSHEV, N. N., The Process of Soil Formation	4
GORSHENIN, K. P., A Contribution to the Classification of Soils	1
KIMBERG, N. V., M. I. KOCHUBEY, and S. P. SUCHKOV, Soil Classification in the Agricultural Districts of Uzbekistan	6
NADEZHDIN, B. V., Some Principles in Classifying Anthropogenic Soils	1

METHODS

ABUKOVA, L. P., Mineralogical Composition of the Clay Fractions of Cirmean Chernozems	12
AFONSKIY, V. L., Ancient Landscapes of Moscow According to a Spore and Pollen Analysis	5
AKHUNDOV, A. K., and K. G. TEYMUROV, Results of Leaching Fine-Textured Soils, Salinized with Sodium Sulfate	5
ALEKSANDROVA, I. V., A Method of Studying the Qualitative Composition of Organic Matter in Soil Solutions	11
ALEKSANDROVA, L. N., The Use of Sodium Pyrophosphate for Isolating Free Humic Substances and Their Organic-Mineral Compounds From the Soil	2
ALEKSEYEV, V. M., V. D. BERDYSHEV, and V. S. BOGOMOLOV, An Electrometer for Measuring Gradient Head When Determining Soil Permeability	6
ALPATOV, V. V., Procedure for Establishing the Connection Between Attributes and Phenomena that are Subject to Spatial Variation	10
ANDREYEV, S. V., and B. K. MARTENS, Soil Moisture Determination by the Method of Nuclear Magnetic Resonance	10
ANDRYUSHCHENKO, I. G., and L. S. GULYAYEV, Practical Application of Oneshty State Farm Agricultural Soil Research in Connection with the Use of Fertilizers	10
ANTYKOV, A. YA., Soil Silvicultural Zoning of the Bryansk Oblast'	8
BILENKO, P. YA., Soil Tillage and the Utilization of Nitrogen and Phosphorus by Winter Wheat	5
BOBCHENKO, V. I., Effect of Preliminary Capillary Wetting on the Swelling and Water Stability of Soils	6
BUD'KO, YE. N., Agricultural-Chemical Characteristics of the Terek River Deposits	6
BUKHMAN, V. A., Characterization of the Agricultural Chemical Properties of Major Peat Soil Groups of Karelia	11
BURYKIN, A. M., Soil Moisture and Erosion in the Humid Subtropical Regions of the USSR	3

INDEX

Number

BUTKEVICH, V. V., Is Phosphorite Broken Down by the Soil or by Plants? 8

CHABART, YAN. N., Soil Moisture Determination by Gamma Radiation 6

CHERNYSHOV, V. A., Water Permeability of Certain Sod-Podzolic Soils 2

DASHEVSKIY, D. I., Improved Method for Determining Adsorbed Ammonia in the Soil 8

DOBRITSKAYA, YU. I., The Titanium Content in Soils of the Yaroslavl Region 3

GENERALOVA, L. G., Effect of Degree of Solonetzization of Soil on Tree Growth in Pot Experiments 8

GERASIMOV, I. P. and O. A. CHICHAGOVA, Two Soil Profiles at Rothamsted Experimental Farms (Rothamsted Experimental Station) 3

GINZBURG, K. E., and G. M. SHCHEGLOVA, Determination of Nitrogen, Phosphorus and Potassium in Plant Material From a Single Sample 5

GOLKIN, D. YE., L. N. LOZANOVA, I. B. PINAYEVA, and L. V. ALEKSANDROVA, Quick and Simple Electrometric Method for Determining Sulfate in Salinized Soils 2

GORBUNOV, N. I., Method of Preparing Soil, Soil Material, River Suspension, and Marine Sediments for Mineralogical Analysis 11

GORDIENKO, I. I., Biogenecoenotic Relationships Between and Nodule Bacteria and the Legumes (Dnieper Broom and White Acacia) on Olesh Sands 8

GRECHIN, I. P., and CH'ENG HSIUNG-SHENG, Influence of Various Concentrations of Gaseous Oxygen in the Air of the Soil on Oxidation-Reduction Conditions 7

GRUZDEV, G. I., Qualitative Assessments of Lands on the Basis of Natural Conditions as Applicable to Horticulture 5

IVANOV, D. N., The GP-21A Flame Photometer 8

IVANOV, D. N., Use of a High Temperature Flame and Large Samples in Spectral Analysis 10

KAO CH'ENG-MIN, Comparative Study of Methods of Determining Water-Permeability Under Conditions of Sod-Podzolic Soils of the Moscow Oblast' 7

KERIMKHANOV, S. U., Spring Erosion of Soil on the Klin-Dmitrov Ridge 11

KISS, I, and I. PÉTERFI, Inhibition of the Activity of Soil Maltase 8

KOROGODOV, N. S., A Letter to the Editor — Criticism of V. V. Dokuchayev's Theory of Factors 4

KOZHEVNIKOV, K. YA., A Rapid and Accurate Method of Determining the Adsorption Capacity of Calcareous Soils 2

KRUGLOVA, YE. K., Boron in the Soils, Cotton, Irrigation and Ground Waters of Golodnaya Steppe 9

KUCHINSKIY, P. A., Apparatus for Mass Particle-Size Analysis of Soils 9

KULIK, N. F., Physical Evaporation of Moisture from Sands and Sandy Soils 4

KULIKOV, N. V., Effect of Ethylendiamine Tetraacetate on the Behavior of Cobalt in Soil and Plants 12

LIGUM, S. T., Simple Attachment to the FEK-M Photoelectric Colorimeter for Emptying Cells 9

MAKAROV, B. N., Determination of Ammonia Evolved from Soil 8

MAKAROV, B. N., Respiration of Soil and Composition of Soil Air on Drained Peat-Bog Soils 2

INDEX

	Number
MALEINA, A. A., Effect of the Systematic Application of Phosphorous Fertilizers and Liming on the Supply of Available Phosphate in Soil	9
MASLOV, B. S., Freezing and Thawing of Peat Soil Under Conditions Prevailing in the Meshchera Lowland	11
MEL'TSER, R. A., Colorimeter Determination of the Phosphorus in Soils and Plants	6
MIKHAYLOV, I. S., Some Features of Sod Arctic Soils on Bolshevik Island	6
MOLOTKOV, P. I., and A. F. POLYAKOV, Methods for Studying Soil Damage when Erosion Follows Clear Cutting of Mountain Forests	8
MUSEROVICH, A., S. BROGOVSKI, and T. SKORUPSKA, Investigation of Organic Matter in Podzolic Cohesive Sandy Soils	2
MYAKINA, N. B., Volumetric Determination of the Sulfate ion in Water Extracts from Soils by Complex-Formation Method	8
NEGOVELOV, S. F., A New M$_{o}$del of a Small Soil Sampler	1
NERPIN, S. V., and M. K. MEL'NIKOVA, An Erroneous Theory of Soil Moisture Movement	2
NIZOVA, A. A., Biological Activity of Soils	10
NOVIKOV, P. M., Constant-Electrode Device for the Study of the Dynamics of Oxidation-Reduction Conditions in Soils	5
ORFANITSKIY, YU. A., M. A. FEDCHENKO, and M. YA. ARDASHEV, Ammonification and Nitrification in the Soils of Certain Types of Cutover Areas in Arkhangel'sk Oblast'	10
PANIN, P. S., Problem of the Influence of Moisture on the Bulk Density of Soils	9
PARSHEVNIKOV, A. L., Biological Activity of Forest Soils in the Kola Peninsula	12
PENKOV, M. D., Problems of the Transition of Southern Chernozems to Dark-Chestnut Soils of the Central Portion of the Crimean Steppe	5
PLATONENKO, M. A., Accuracy in Mapping Soils From Aerial Photographs	1
PLOTNIKOV, A. A., The Dynamics of Water-Stable Soil Structure in a Grass-Arable Rotation	10
POLYAKOV, YU. A., and I. T. GERMOGENOVA, Use of Interferometry in Soil Chemical Studies	12
POPOV, V. I., S. F. Negovelov's Soil Sampler	1
PROSTAKOV, P. YE., Regulation of Nitrification Processes on Ciscaucasian Carbonate Chernozems During Irrigation	1
RABIN, A. E., Compilation of a Bibliography on the Soils of the USSR According to Zones	9
RADENKOVA-KARAIVANOVA, M. and IVAN DONCHEV, Residual Effect of Superphosphate in the Smolnitza Group of Soils	1
RIN'KIS, G. YA., Procedure for Determining the Total Contents of Microelements in Soils and Plants	3
RUNOV, YE. V., and O. S. TEREKHOV, Problem of the Catalase Activity in Certain Forest Soils	8
SHATEMIROV, K. SH., A Rapid Method of Determining Adsorbed Sodium and Potassium in Calcareous Soils	2
SHAVRYGIN, P. I., Formation of the Chemical Composition of Soil Solutions under the Influence of Ground Water	12

INDEX

	Number
SHTINA, E. A., Methods of Assessing Soil Algae as a Component of the Microflora of Soil	5
SHUMAKOV, V. S., and A. I. MIKHOVICH, The Phenomenon of Impulverization in the Area of Elista	7
SHURYGINA, YE. A., Significance of the Adsorption of Cations when Determining Clay Minerals in Clays and Soils	9
SIMAKOV, V. N., and V. P. TSYPLENKOV, A Modification of Humus Determination by the Volumetric Method (For Mass Analysis)	4
SMIRNOV, M. P., The Rate of Soil Formation in Old Quarries of Calcareous Rocks and Secondary Changes in Buried Light-Grey Forest Soils	4
SMIRNOVA, L. F., Wind Erosion of Coarse-Textured Soils in Pavlodarskaya Oblast'	2
SOKOLOV, A. V., The Presence of Exchangeable Aluminum in Soils	1
SOKOLOVSKIY, S. P., Water-Physical Properties of Chestnut and Brown Soils in Certain Districts of the Mongolian People's Republic	10
STARCHENKO, I. I., Problem of Calculating the Width of Forest Shelterbelts for Erosion Control	7
TARASENKO, B. I., Mechanical Stability of Aggregates in Western Ciscaucasian Chernozems	10
TIKHONOV, A. V., Soil Erosion and its Effects on Yield in Areas of the Volga Upland	2
To Intensify the Development of Rational Methods for Field and Laboratory Soil Investigations, an Editorial	2
TOLSTOUSOV, V. P., Increasing the Productivity of Brown Solonetzic Spots in a Chernozem Complex	10
TRAVLEYEV, A. P., The Role of Forest Litter in Heat Insulation	10
TRUSHIN, V. F., Extent of Soil Erosion in Relation to the Main Method of Tillage	4
TSAP, M. L., and G. L. LINNIKOVA, A Photometric Method of Determining Total Phosphorus in Soil	2
TSYPLENKOV, V. P., A Tritration Device for the Volumetric Method of Humus Determination	4
VIL'GUSEVICH, I. P. and N. P. BULGAKOV, Microelement Content in the Soils of Byelorussia	3
VOYKIN, I. M., Phosphate Conversion in the Soils of the Tatar Republic	1
YAKUSHEVSKAYA, I. V., Microelement Content in Certain Soils of the Vladimir Region	6
YAO SIAN-LIAN, Comparative Study of the Clay Fraction of Typical Sierozem when Preparing Soil by Various Methods for Particle-Size Analysis	9
ZAIMOV, K. K. and V. A. FIL'KOV, Peculiar Features of the Organic Matter in Moldavian Chernozems	10
ZAYDEL'MAN, F. R., and V. G. VINOGRADOV, The Lower Limit of Available Moisture for Plants in Peat Soils	7
ZAYTSEV, B. D., Characteristics of Northwest Caucasian Brown Forest Soils	12

CHRONICLE

ALEKSAKHIN, R. M., and V. D. VASIL'YEVSKAYA, The Second Inter-University Conference on the Problem of Microelements and the Natural Radioactivity of USSR Soils	9

INDEX

	Number
ANDREYEVA, YE., Conference on Site Quality and Chemical Characteristics of USSR Soils	6
BUSHINSKIY, VLADIMIR PETROVICH, by a group of colleagues	12
CHERNOV, VASILIY ANDREYEVICH (Obituary)	11
DOBROVOL'SKIY, G. V., N. P. Remezov, on the Occasion of his 60th Birthday and 40th Anniversary of Scientific Activity	8
GILYAROV, M. S., International Soil Biology Journal	11
KARAVAYEV, V. N., Seminar on the Use of Soil Materials	11
KONONOVA, M. M., N. P. BEL'CHIKOVA, and I. V. ALEKSANDROVA, Conference on Methods of Studying Humus	11
ORLOVSKIY, NIKOLAY VASIL'YEVICH, by Colleagues and Students	1
RAZORENOVA, N. A., Report of the Activity of the All-Union Society of Soil Scientists in 1959	4
RODE, A. A., How Not to Use Analytic Data in Studying Soil Genesis	11
RODE, A. A., Reply to N. N. Bolyshev	9
SOBOLEV, S. S., Professor D. G. Vilenskiy's Main Scientific Works Concerned with Soil Science	10
STOL'GANE, ALEKSEY ALEKSANDROVICH, by a group of colleagues	12
STRANSKIY, IVAN FEDOROVICH (APRIL 18, 1886-OCTOBER 29, 1959) (Obituary)	7
SUKACHEV, ACADEMICIAN VLADIMIR NIKOLAYEVICH (Award of Medal)	6
TROITSKIY, YEVGENIY PETROVICH, by Soil Department, Biological and Soil Faculty of Moscow State University	12
TYURIN ACADEMICIAN IVAN VLADIMIROVICH (Birthday)	6
TYURIN, I. V., General Results and Future Outlook of Work of the V. V. Dokuchayev Soil Institute, Academy of Sciences, USSR	5
VERSHININ, PETER VASIL'YEVICH, by Members of the Agrophysical Institute	9
VILENSKIY, D. G., (July 1, 1892-February 13, 1960)	10
VOZNESENSKIY, ALEKSEY SEMENOVICH, by the Georgian Research Institute for Hydrotechnical Engineering and Melioration, Academy of Agricultural Sciences, Georgian Soviet Republic	4
YAKUBOV, T. F., An American Soil Scientist's Impressions of the USSR	11

REVIEWS

ALEKSANDROVA, V., The Forces of the Land (Stories About the Soil)	3
CHAYANOV, S. K., Reclamation of Virgin Land in the Semi-Desert	7
FRIDLAND, V. M., Symposium in the United States on Soil Genesis	6
LENEUF, N., Weathering of Calcareous-Alkaline Granites and Granodiorites in the Forest Zone of the Ivory Coast, and the Soils Derived from Them	11
PETERBURGSKIY, A. V., Exchangeable Adsorption in the Soil and the Availability of Nutrients by Plants	8
POL'SKIY, B. N., Stories About the Soil (For Middle-School Students)	3
REMEZOV, N. P. and R. M. ALEKSAKHIN, Forest Soils, Their Properties and Relation to Silviculture	1

INDEX

Number

SCHEFFER, F., and B. ULRICH, Textbook on Agricultural Chemistry and Soil Science 8

Soils of Bulgaria, published by the USSR Academy of Sciences 3

ZONN, S. V., V. N. SMIRNOV, and A. A. MOLCHANOV, The Teaching of Soil Science in Forestry Colleges and the Textbook of Professor A. A. Rode 2

AIBS Russian Monograph Translations

The AIBS is in the process of expanding its Russian Translations Program extensively. Funds to subsidize ranslation and publication of important Russian literature in biology have been obtained from the National Science Foundation, as part of a larger program to encourage the exchange of scientific information between he two countries. The following monographs have been published:

Origins of Angiospermous Plants. *By A. L. Takhtajan*
Edited by G. Ledyard Stebbins. Translated by Olga H. Gankin
68 pp. [13 illustrations] 8½ x 10¾. $3.00, individuals and industrial libraries (U.S. & Canada); $2.00, AIBS members and all other libraries; $.50 additional, foreign.

Essays on the Evolutionary Morphology of Plants. *By A. L. Takhtajan*
Edited by G. Ledyard Stebbins. Translated by Olga H. Gankin
144 pp. [32 illustrations] 8½ x 10¾. $5.00, individuals and industrial libraries (U.S. & Canada); $4.00, AIBS members and all other libraries; $.50, additional, foreign.

Problems in the Classification of Antagonists of Actinomycetes. *By G. F. Gause*
Edited by David Gottlieb. Translated by Fritz Danga
165 pp. [18 illustrations] 7 x 10. $5.00, individuals and industrial libraries (U.S. & Canada); $4.00, AIBS members and all other libraries; $.50, additional, foreign.

Arachnida. Vol. IV, No. 2. Fauna of the U.S.S.R. *By B. I. Pomerantzev*
Edited by George Anastos. Translated by Alena Elbl.
199 pp. [638 illustrations] 7 x 10. $10.00, individuals and industrial libraries (U.S. & Canada); $9.00, AIBS members and all other libraries: $1.00, additional, foreign.

Arachnoidea. Vol. VI, No. 1. Fauna of the U.S.S.R. *By A. A. Zachvatkin*
Translated and edited by A. Ratcliffe and A. M. Hughes
567 pp. [705 illustrations] 7 x 10. $10.00, individuals and industrial libraries; (U.S. & Canada); $9.00, AIBS members and all other libraries; $1.00, additional, foreign.

Marine Biology. Trudy Institute of Oceanology. Vol. XX. *Edited by B. N. Nikitin*
302 pp. [66 illustrations] 8½ x 10¾. $10.00, individuals and industrial libraries; (U.S. & Canada; $7.50, AIBS members and all other libraries; $1.00, additional, foreign.

Plants and Xrays. *By L. P. Breslavets*
Editor of English Edition: Arnold H. Sparrow
115 pp. [26 illustrations] 7 x 10. $5.00, individuals and industrial libraries (U.S. & Canada); $4.00, AIBS members and all other libraries; $.50, additional, foreign.

Wintering of Plants. *By I. M. Vasil'yev*
Editor of English edition: Jacob Levitt.
$9.00, individuals and industrial libraries (U.S. & Canada); $8.00, AIBS members and all other libraries; $.50, additional, foreign.

Monogenetic Trematodes, Their Systematics and Phylogeny. *By Boris E. Bychowsky.*
Editor of English edition: William J. Hargis, Jr.
$10.00, individuals and industrial libraries (U.S. & Canada); $9.00, AIBS members and all other libraries; $.50, additional, foreign.

For orders and a FREE copy of our Publications Catalog listing all AIBS Publications, write to:

AMERICAN INSTITUTE OF BIOLOGICAL SCIENCES
2000 P Street, N.W. Washington 6, D. C.

AGRONOMY SEMINAR
305 DAVENPORT HALL

TRANSLATIONS OF RUSSIAN BIOLOGICAL JOURNALS

The American Institute of Biological Sciences, under a grant from the National Science Foundation, is currently translating and publishing seven Russian research journals in biology.

DOKLADY: BIOLOGICAL SCIENCES SECTION

6 issues per year. First issues published: 1957, Vols. 112-117. Current issues published 1961, Vols. 136-141.

Subscriptions:

$20.00 per year, individuals and industrial libraries (U.S.A. & Canada)
$15.00 per year, AIBS members and all other libraries
$2.50 additional to each price, foreign
$4.00 each, single copies

DOKLADY: BOTANICAL SCIENCES SECTION

6 issues per year. First issues published: 1957, Vols. 112-117. Current issues published 1961, Vols. 136-141.

Subscriptions:

$7.50 per year, individuals and industrial libraries (U.S.A. & Canada
$5.75 per year, AIBS members and all other libraries
$1.50 additional to each price, foreign
$1.50 each, single copies

DOKLADY: BIOCHEMISTRY SECTION

6 issues per year. First issues published: 1957, Vols. 112-117. Current issues published 1961, Vols. 136-141.

Subscriptions:

$15.00 per year, individuals and industrial libraries (U.S.A. & Canada)
$10.00 per year, AIBS members and all other libraries
$3.00 additional to each price, foreign
$4.50 each, single copies

PLANT PHYSIOLOGY • FIIZIOLOGIYA RASTENIY

6 issues per year. First issues published: 1957. Vol. 4, Nos. 1-6. Current issues published: 1961, Vol. 8, Nos. 1-6.

Subscriptions:

$15.00 per year, individuals and industrial libraries (U.S.A. & Canada)
$11.00 per year, AIBS members and all other libraries
$2.00 additional to each price, foreign
$3.00 each, single copies

SOVIET SOIL SCIENCE • POCHVOVEDENIYE

12 issues per year. First issues published: 1958. Current issues published: Jan.-Dec., 1960.

Subscriptions:

$20.00 per year, individuals and industrial libraries (U.S.A. & Canada)
$15.00 per year, AIBS members and all other libraries
$2.50 additional to each price, foreign
$4.00 each, single copies

MICROBIOLOGY • MIKROBIOLOGIYA

6 issues per year. First issues published: 1957, Vol. 26, Nos. 1-6. Current issues published: 1961, Vol. 30, Nos. 1-6.

Subscriptions:

$40.00 per year, individuals and industrial libraries (U.S.A. & Canada)
$20.00 per year, AIBS members and all other libraries
$3.00 additional to each price, foreign
$4.50 each, single copies

ENTOMOLOGICAL REVIEW
ENTOMOLOGICHESKOYE OBOZRENIYE

4 issues per year. First issues published: 1958. Current issues published: 1961, Vol. 40, Nos. 1-4.

Subscriptions:

$25.00 per year, individuals and industrial libraries (U.S.A. & Canada)
$12.00 per year, AIBS members and all other libraries
$3.00 additional to each price, foreign
$7.50 each, single copies

Order from:

AMERICAN INSTITUTE OF BIOLOGICAL SCIENCES
2000 P Street, N.W.
Washington 6, D. C.